A
Dictionary
of
Chemistry

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A
DICTIONARY
OF
CHEMISTRY.

I. **ABSORBENT.** (a)
II. **ACETOUS.** (b)
III. **ACESCENT.**

This word may be employed to denote a matter, which either is turning ſour, that is to ſay, acid, or which is ſlightly acid. *See* Acid. (c)

IV. **ACID.** Acids are of all ſaline ſubſtances the moſt ſimple, and conſequently ought to be conſidered as *ſecondary principles.* Their name is derived from their taſte, which is acid or ſour. One of the marks by which they are eaſily known, is their property of changing into red the blue colors of an infuſion of flowers of violets, or of the tincture of heliotropium. (d)

If acids were ſeparated from all moiſture or water, and from all other ſubſtances not neceſſary to their ſaline eſſence, they would appear under a concrete or ſolid form. But gene[illegible] they are liquid; becauſe their affinity to water is ſo great, that when they contain no more than what is neceſſary to conſtitute them ſalts, they are ſtrongly diſpoſed to ſeize more water, whenever they can touch it; and as the atmoſphere is always loaded with watery vapors, the contact of the air is ſolely ſufficient to render acids fluid, by their rapid union with its moiſture.

(a) ABSORBENT. Thoſe *earths* are called *abſorbent*, which are capable of being combined with acids. Theſe are calcareous earths, aſhes of burnt vegetable and animal ſubſtances, magneſia, and earth of alum. This claſs of earths might be more properly denominated *alkaline earths.* *See* Earth, Magnesia, Alum.

(b) ACETOUS. *Acetous acid* is the ſame as vinegar. *Acetous fermentation* is that fermentation by which vinegar is produced. *Acetous ether* is an ether made by means of vinegar. *See* Vinegar, and Ether.

(c) The word *aceſcent* can only be properly applied to denote the firſt of theſe meanings. The ſecond may be expreſſed by either of the words, *acidulous* or *ſubacid.*

(d) This property of changing the blue, and of heightening the red colors of vegetables, is not common to all acids, for the volatile ſulphureous acid deſtroys theſe colors: nor is it peculiar to acids; for alum, a neutral ſalt, produces the ſame effect.

Acids have a general tendency to unite with almoſt all ſubſtances, particularly with thoſe which are either ſimple, or not much compounded; as phlogiſton, alkaline ſalts, fixed and volatile, earths, (eſpecially thoſe called *abſorbent*), metallic ſubſtances, water, and oil.

Many ſubſtances are by chemiſts called *acids*, becauſe they poſſeſs thoſe general properties which we have mentioned. But theſe ſubſtances differ from each other by properties peculiar to each.

As acids from their tendency to unite, and to remain united with almoſt all other bodies, are never found ſingle and pure, but muſt be obtained and ſeparated by artificial operations from the bodies with which they happen to be combined; they have been diſtinguiſhed by authors into claſſes, according to the ſubſtances whence they are extracted. Theſe claſſes are *mineral acids*, *vegetable acids*, and *animal acids*. In Mr. Geoffroy's Table of Affinities, thoſe of acids are marked in the following order: fixed alkali; volatile alkali; earths; metallic ſubſtances. (*e*)

Very concentrated acids taken internally in a doſe ſomewhat large; for inſtance, an ounce, or even much leſs, when the acid is ſuſceptible of great concentration; are corroſive and genuine poiſons. Their beſt antidotes are alkaline ſubſtances, either ſaline or earthy, oils, alkaline ſoaps, large quantities of mild drink, as water, milk, mucilages. Theſe muſt be given copiouſly and ſpeedily.

Small doſes of acids diluted with much water, ſo as to be agreeably acidulous, and blunted by ſome mild ſubſtance, as ſugar, are excellent cooling and aperitive medicines, fit to quench exceſſive thirſt, and leſſen the acrimony of the bile. They are chiefly uſeful in alkaleſcent diſpoſitions, and in putrid, inflammatory fevers. Their whole action ſeems to be exerted on the primæ viæ; for they are rendered unactive by the powers of digeſtion, by means of which they are combined with the earthy and oily parts of aliments and digeſtive juices. They would be certain poiſons if they paſſed into the blood veſſels with their acid qualities, at leaſt with their acidity undiminiſhed. They would coagulate the blood, and would greatly irritate the nervous and ſenſible parts. Malpighi killed a dog by injecting into the veins ſuch a quantity of nitrous acid, as would not have hurt, if it had been ſwallowed. Acids employed externally ſhew ſimilar qualities, but more ſenſibly than when impaired by the digeſtive powers. They are uſeful againſt alkaleſcent putridity. (*f*)

(*e*) The *affinities or powers of union of acids* are, 1. Fixed alkali; 2. Calcareous earth; 3. Volatile alkali, and magneſia, the powers of union of theſe two being nearly equal; 4. Iron, zinc, copper, and perhaps ſome other metals; 5. Earth of alum; 6. The remaining metals.

(*f*) I. The *common properties of acids* are, 1. They may be united with water. This is not merely a dilution of acids, for by uniting them with a certain quantity of water, heat or cold is produced; and the mixed fluid acquires a ſpecific gravity, different from the inter-

V. **ACIDS (ANIMAL).** This name is given to acids obtained from certain animal matters; as butter, fat, blood, ants, and moſt flies.

Theſe acids have been too little examined to enable us to judge whether they be eſſentially different from thoſe obtained from vegetables. But we are certain, that they differ in the ſame circumſtances as the vegetable acids do from mineral acids; and probably, this difference proceeds from the ſame cauſe

intermediate gravity of its component parts. From this union, therefore, a new compound is formed. 2. They may be combined with ſpirit of wine. *See* ETHER. 3. They may be combined with abſorbent earths. 4. They may be combined with alkaline ſalts. 5. They may be combined with metallic ſubſtances. Although every acid does not directly diſſolve every metallic ſubſtance, yet probably by concentration or dilution of the acid, diviſion of the metals by mechanical and chemical methods, by application of ſufficient heat, and other means, every metal may be acted upon by every acid. 6. They may be combined with phlogiſton, and with oils. 7. When they combine with theſe ſubſtances, they diſengage from them all or part of the fixable air which they contain. 8. They ſoften and diſſolve the ſolid parts of animals. 9. They coagulate moſt of the liquid parts of animals. 10. They change to red the blue, and heighten thered colors of vegetables, excepting volatile, ſulphureous acid, which deſtroys theſe colors. Probably this change of color proceeds from the action of acids upon the oily parts of vegetables; for oils are rendered red by ſufficiently concentrated acids. 11. They reſiſt fermentations. 12. They are not capable of being frozen by ſo ſmall a degree of cold as water is. 13. They produce cold when poured upon ice.

2. As acids ſo powerfully attract water, that they are never found pure and dry, but always in a fluid ſtate, when uncombined with earths, alkalies, or metals, we cannot eaſily aſcertain the quantity of acid contained in acid liquors. Homberg has attempted to eſtimate the quantity of acid contained in the acid ſpirits of vinegar, nitre, ſea-ſalt, and of vitriol, by combining theſe liquors with ſalt of tartar, ſo as to form neutral ſalts; imagining that the weight gained by that alkali from its union with acids, or the difference betwixt the weight of the ſalt of tartar and the neutral ſalt produced, was equal to the weight of real acid contained in the quantity of acid liquor employed. But as he did not conſider, that the air expelled from ſalt of tartar, during its combination with acids, makes a very conſiderable part of the weight of that alkali, the inferences from his experiments are not juſt; and the real quantity of acid contained in an acid liquor, is ſo much more than the quantity inferred by him, as the whole weight of the fixable air diſengaged from the ſalt of tartar. The quantity of fixable air contained in ſalt of tartar varies much according to the method of its preparation, and other circumſtances; but if we ſuppoſe that the fixable air in the ſalt of tartar, uſed by Homberg, was in as great a proportion as in the pearl-aſhes of Mr. Cavendiſh, [Phil Tranſ. 1766] that is $\frac{284}{1000}$ of the whole weight of the alkali, by adding $\frac{284}{1000}$ of the alkali uſed in each experiment, we ſhall nearly find the true quantity of ſolid acid in each neutral ſalt. The firſt column ſhews the quantity of each of the acids employed to ſaturate an ounce of ſalt of tartar; and the ſecond column ſhews the quantities of the neutral ſalts produced.

1.	2.
Diſtilled vinegar, 14 oz.	oz. 1. dr. 3. gr. 36.
Spirit of ſalt, oz. 2. dr. 5.	oz. 1. dr. 3. gr. 14.
Spirit of nitre, oz. 1. dr. 2. gr. 36.	oz. 1. dr. 3. gr. 10.
Acid of vitriol, dr. 5.	oz. 1. dr. 3. gr. 5.

Homberg ſuppoſes, that in each of the neutral ſalts, the quantities of which are mentioned in the ſecond column, the quantity of contained alkaline ſalt is equal to an ounce, and the quantity of contained acid is equal to the remaining weight; whereas which conſtitutes the difference betwixt the vegetable and mineral acids; namely, the combination of oily particles with the former. (*g*)

The *phoſphoric acid*, obtained from urine, appears, for the ſame reaſon, to belong to this claſs of animal acids. But it has properties ſo different from thoſe

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by our propoſed method of correction, ſuppoſing ſtill that the quantity of fixable air in his ſalt of tartar was $\frac{284}{1000}$ of the whole weight, we ſhall find that of the oz. 1. dr. 3. gr. 5. of vitriolated tartar in the laſt mentioned inſtance of the table, dr. 5. gr. 44. were fixed alkali deprived of its air, and dr. 5. gr. 21. were acid. Hence we may perceive that the quantities of alkali and of acid in the ſeveral neutral ſalts, the weights of which are expreſſed in the ſecond column of the table, are very nearly equal. *See* AIR (FIXABLE.)

3. The *known acids* are, 1. Vitriolic acid. 2. Nitrous acid. 3. Marine acid. 4. Acetous acid. 5. Vinous acid, or tartar. 6. Eſſential acid of vegetables. 7. Acid obtained by diſtillation of vegetables. 8. Acid of bitumens. 9. Acid of borax. 10. Acid obtained by diſtillation of oils, reſins, and fats. 11. Phoſphoric acid. 12. Acid of ants and other inſects. 13. Acids of healthy and of diſeaſed ſtomachs of animals. 14. Acid of perſpirable matter of diſeaſed animals. Perhaps the number of acids is much larger; or perhaps ſome of theſe are only modifications of other primary acids; or laſtly, as Stahl ſuppoſes, they are all modifications of the one only primary acid, namely, that of vitriol. *See the theory of acids under the article* SALT.

(*g*) The acid of ants may be perceived by ſmell, on turning up an ant-hill in ſpring or ſummer. When theſe inſects are irritated, they diſcharge a fluid which has an acid taſte and ſmell. Water, or ſpirit of wine, in which they are agitated, becomes acidulous. Part of this acid is ſo volatile as to riſe by diſtillation with ſpirit of wine, in which ants had been immerſed; but the greateſt part of it is ſo fixed, as to remain united with the reſiduous phlegm. All the acid may be extracted by water, and rendered capable of riſing by diſtillation with that fluid in a water-bath. From 24 ounces of freſh ants were obtained by diſtillation, without addition, eleven ounces and two drams of acid ſpirit, ſome urinous ſalt and ſpirit, ſome empyreumatic oil, and a reſiduum, conſiſting of earth and fixed ſalt. This acid is found to have the general properties of acids. With fixed alkalies it forms neutral cryſtals, oblong, and deliqueſcent. Theſe cryſtals being diſtilled by a violent fire, yielded a liquor ſcarcely acid, and another liquor urinous or ammoniacal. From the reſiduum diſſolved in water, by filtration and evaporation, were obtained large cryſtals which did not deliquiate, and had the general properties of fixed alkalies. In this experiment the acid ſeemed to diſappear. But by pouring oil of vitriol on theſe alkaline cryſtals, white vapors were diſengaged, although no acid ſpirit could be obtained by diſtillation. From theſe white vapors, and from the facility with which this ſalt cryſtalizes, Mr. Margraaf, from whom theſe and the following experiments on the acid of ants are extracted, ſuſpects the exiſtence of a latent acid. The acid of ants formed with volatile alkali an ammoniacal fluid, which, like the combination of the ſame alkali with vinegar, could not be reduced to a concrete or ſolid ſtate. With quicklime, chalk, and coral, it formed dry cryſtals.

This acid did not precipitate ſilver, lead, or mercury, from nitrous acid; hence it has no analogy to marine acid. Nor did it precipitate quicklime from marine acid; and hence it has no analogy to vitriolic acid.

As a menſtruum, this acid acted weakly upon copper, and ſtrongly upon iron and upon zinc; but it did not act, or very little, upon ſilver, lead, tin, regulus of antimony and biſmuth. Its combination with iron cryſtallized; in which reſpect it differs from vinegar. It diſſolved the calxes of copper, ſilver, zinc, and lead; but not the calxes of tin, regulus of antimony, biſmuth, or of mercury, which laſt calx it converted to fluid quickſilver. Upon the whole (ſays Margraaf), we may perceive a reſemblance in many reſpects, though not in all, betwixt this acid and the acetous. *See the Memoirs of* of all other acids, that it deſerves to be conſidered as a diſtinct acid. *See* PHOSPHORUS.

VI. ACIDS (CONCRETE). Theſe are ſaline, ſolid ſubſtances which have the general properties of acids. Such are, *cryſtals of tartar*; *eſſential ſalts of vegetables*, particularly of thoſe which are acid; the *volatile acid ſalt of amber*, and of ſome other *bitumens*; and *flowers of Benjamin*.

VII. ACID *of* VINEGAR. *See* VINEGAR.

VIII. ACIDS (FLUOR), Are thoſe which are generally, or always in a fluid ſtate; ſuch are the volatile vitriolic, nitrous, marine acids, and thoſe obtained by diſtillation from vegetable and animal ſubſtances.

IX. ACID (MARINE). This is ſo called, becauſe it is generally obtained from ſea-ſalt; though it may be alſo procured from *Sal-gem*, or *foſſile ſalt*, and from the ſalt of ſaline fountains and pits, ſince all theſe ſalts are different from ſea-ſalt, only as to their origin.

The marine acid, as well as the nitrous and vitriolic, is never found alone and pure; but it is always combined with an alkali, ſo as to form a neutral ſalt, which is diſſolved copiouſly in the ſea, to which it gives a ſalt taſte.

This neutral ſalt is alſo found cryſtallized in large tranſparent maſſes within the earth, and is then called *Sal-gem*, or *foſſile ſalt*.

It is alſo diſſolved in the waters of ſome *wells* or *fountains*, which may be owing to theſe waters communicating by ſubterraneous paſſages with the ſea, or to their paſſing through mines of *Sal-gem*.

The marine acid has all the general properties of ſaline acid ſubſtances.

It differs from the vitriolic acid in the following circumſtances: it is more ligh and volatile; it has ſmell and color; it emits vapors; it has leſs affinity with fixed alkalies and abſorbent earths; and, like the nitrous acid, it forms with abſorbent earths no ſalts but ſuch as are deliqueſcent.

It differs from the nitrous acid by its color, which is more yellow and leſs red; by the whiteneſs of its vapors, which are viſible only in open air; by its ſmell, which reſembles ſaffron; by a weaker affinity with abſorbent earths and fixed alkalies. *(b)*

The marine acid cannot be ſo much concentrated as the vitriolic and nitrous acids, becauſe it is more volatile.

This acid cannot be ſo eaſily combined with phlogiſton as the vitriolic and nitrous, and we are not certain that ſome medium is not requiſite for ſuch a combination.

Although the properties of the marine acid are as well known as thoſe of nitrous and vitriolic, yet chemiſts are far from underſtanding the nature of this ſaline ſubſtance equally well. Becker, according to his theory of acids, attributes the diſtinguiſhing properties of the marine acid to that principle which

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the Berlin Academy, vol. 4. 1749, or the *Opuſcules Chemiques de Mr. Margraaf*.

Inſects armed with ſtings, as bees, waſps, and hornets, when irritated, diſcharge an acid liquor.

(b) Marine acid differs from the nitrous in another inſtance, beſides thoſe mentioned in the text. It readily diſſolves metallic calxes, which are little affected by nitrous acid. Hence it extracts from moſt colored earths and ſtones the metallic calxes, by which the color of theſe ſubſtances is produced.

he calls *mercurial earth*. But he ſupports his opinion by no other proofs, than by ſome appearances cauſed by the union of this acid with metallic ſubſtances, in which alſo he ſuppoſes this mercurial earth to be a component part. But as the exiſtence of this mercurial earth in marine acid, or in metallic ſubſtances, is not demonſtrated, nor even ſufficiently indicated; and as Becker has explained himſelf very obſcurely and confuſedly on this ſubject, what he has ſaid does not merit a deliberate diſcuſſion. Stahl, therefore, who was too judicious to be ſatisfied with appearances and probabilities, abandoned, in ſome meaſure, this part of Becker's theory, and only expreſſes a wiſh that the exiſtence of the mercurial earth could be as well aſcertained as the exiſtence of phlogiſton.

This great chemiſt, however, appears to be convinced of the primary identity of all ſaline ſubſtances; that is to ſay, he believed that they all were the vitriolic acid diſguiſed by ſome mixture. He aſſures us, even, that he has been able to tranſmute acids into each other; that is, to change the vitriolic acid into the nitrous and marine; and to reduce theſe back again into the vitriolic. But he has not publiſhed his experiments on this ſubject, perhaps becauſe he had not ſufficiently aſcertained the proceſſes, or that he choſe to reſerve to himſelf ſuch important diſcoveries. The poſſibility, therefore, of theſe tranſmutations of acids is not yet determined. (*i*)

The properties of the marine acid, above-mentioned, indicate nothing more than that it participates of the nature of both the vitriolic and nitrous acids.

Its combination with phlogiſton, which, of all its properties, might aſſiſt us moſt in our inveſtigation, has not been ſufficiently explained.

The unſucceſsful attempts made by M. Margraaf, a celebrated chemiſt of the academy of Berlin, to combine the marine acid pure and crude, as he calls it, with phlogiſton, with a view to compoſe phoſphorus, are ſo many freſh cauſes of uncertainty, and additional motives to endeavor the illuſtration of this important object. *See* PHOSPHORUS.

Marine acid, combined to the point of ſaturation with marine alkali, called alſo mineral or foſſil alkali, forms a neutral ſalt, cryſtalizing in cubes, of an agreeable, ſalt taſte. *See* COMMON SALT under the article SALT.

With volatile alkali it forms a neutral, cryſtalized, and very pungent ſalt. This ſalt is ſemi-volatile, and may be ſublimed with a certain degree of heat. It is called *Sal ammoniac*. *See* AMMONIAC.

Metallic ſubſtances are in general more difficultly diſſolved by the marine than by the vitriolic and nitrous acids, becauſe the firſt has leſs affinity than the other two with phlogiſton, which is the medium of union betwixt metals and acids.

Marine acid, when fluid, however much concentrated, and aſſiſted by any heat, cannot diſſolve gold, ſilver, platina, or mercury, in their natural or metallic ſtate. It combines however very well and intimately with ſilver and mercury by two methods. One of theſe is called the dry method or cementation, becauſe the acid then, in ſome meaſure, is dry, and expoſed to the greateſt heat it is capable of receiving. *See* PARTING (CONCENTRATED) and SUBLIMATE

(*i*) Concerning the identity of acids, ſee the article SALT. Concerning the tranſmutation of marine acid into the acid of nitre, *ſee* alſo ACID (NITROUS).

(CORROSIVE). The ſecond method is called the *humid way*, and conſiſts in ſeparating theſe metals from their ſolutions in nitrous acid. *See* LUNA CORNEA, and PRECIPITATE (WHITE).

This acid, when pure and unmixed, cannot by any known method diſſolve gold or platina. But when it is mixed with the nitrous acid, it forms a menſtruum called *aqua regia*, which readily diſſolves theſe metals. *See* AQUA REGIA. From combinations of aqua regia with gold or platina, metallic ſalts are formed ſuſceptible of cryſtalization. *See* GOLD, and PLATINA. (*k*)

Pure marine acid diſſolves ſufficiently well tin, lead, copper, iron, zinc, and biſmuth; and leſs eaſily regulus of antimony: and it forms with theſe metals different ſalts, the properties of which ſee under the articles TIN, LEAD, &c. (*l*).

The general phenomena, moſt remarkable in the combination of marine acid with metallic matters, are;

1. It diſſolves theſe ſubſtances with leſs heat and effervescence, and with fewer vapors, than nitrous acid does. This obſervation is true, even with reſpect to thoſe metals which it diſſolves moſt readily, as copper and iron.

2. It forms with all the metals which it diſſolves, excepting iron and copper, ſalts capable of cryſtalization. The cauſe of this property is, that generally it takes from metals much leſs of their phlogiſton than the nitrous acid does.

3. The metals with which it contracts the ſtrongeſt union, as ſilver, lead, mercury, and the regulus of antimony, are actually thoſe with which it unites moſt difficultly. We muſt here obſerve, that marine acid ſeparates ſilver, lead, and mercury, from the nitrous acid in which they had been previouſly diſſolved; and when it is once united with theſe metals, they adhere more ſtrongly to it, than they did to the nitrous acid. This has given occaſion to Becker and other chemiſts to advance, that in marine acid, and in the laſt mentioned metals, there is more of that principle which they call *mercurial earth*, than in any other acids or metals. And to this abundance of mercurial earth, they attribute the ſtronger connection of marine acid, and the mentioned metals, which are diſtinguiſhed from all others by the appellations *white*, *lunar*, and *mercurial*.

4. Marine acid has the property of volatiliſing, or carrying off with it in ſublimation or diſtillation, entirely or partly, the metals with which it is united, thoſe particularly with which it forms the ſtrongeſt union, as mercury, regulus of antimony, ſilver, and lead. *See* SUBLIMATE (CORROSIVE), LUNA CORNEA, BUTTER of ANTIMONY, and PLUMBUM CORNEUM.

5. Marine acid, though in ſome reſpects leſs ſtrong than the vitriolic or nitrous, forms with metallic ſubſtances, and particularly with the laſt mentioned metals, with which it adheres moſt firmly, *metallic ſalts*, much more corroſive than thoſe formed by the other two acids. *See* CAUSTICITY.

(*k*) By two methods gold and platina may be rendered ſoluble in marine acid: 1. by previous ſolution in aqua regia, and precipitation from that menſtruum by means of an alkali; or, 2. by a previous calcination with tin or biſmuth.

(*l*) Marine acid, when boiling, diſſolves arſenic. Regulus of cobalt, and the ſemi-metal called nickel, are alſo ſoluble in marine acid: the ſolution of the former is reddiſh yellow, which is changed to green by application of heat; and the ſolution of the latter is of a deep green color.

The greateſt part of theſe phenomena, peculiar to marine acid, evidently proceeds from the difficulty with which it unites with phlogiſton, and to the ſmallneſs of the quantity of that principle which it takes from metallic ſubſtances.

However, theſe phenomena, thus collected, may, by being compared together, furniſh matter for curious ſpeculations concerning the famous mercurial earth of Becker, which, according to him, is the third principle of metallic ſubſtances. Beſides, in moſt ſolutions of metals by marine acid, a ſingular ſmell, reſembling the ſmell of garlic, or of arſenic, is exhaled: but, according to Becker, arſenic contains abundantly the mercurial principle.

The difficulty with which marine acid combines with the inflammable principle, is the reaſon why this acid acts ſo little upon oils and oily ſubſtances. It ſeems to have no power over theſe ſubſtances when it is fluid and united with a certain quantity of water. What it would produce, if it were artfully applied to theſe oleaginous matters in its higheſt degree of concentration, with the help of conſiderable heat, is not known. Very intereſting reſearches remain yet to be made upon this ſubject.

It appears that the inflammable principle, when intimately united with water, as in ardent ſpirits, is in the favorable ſtate for combination with marine acid; although many more difficulties are found in making this combination with the marine acid, than with the vitriolic or nitrous.

Marine acid, mixed with ſpirit of wine in all proportions, and even frequently diſtilled with it, is much leſs intimately combined than the other two acids, and proportionably loſes leſs of its acidity than they do. *See* SPIRIT of SALT (DULCIFIED).

Lately, however, marine acid has been applied to ſpirit of wine in ſuch a manner, that from their union reſults a liquor which has the diſtinguiſhing properties of ether, and is a true *marine ether*. *M. Baumé*, an able artiſt, and excellent obſerver, was the firſt who publiſhed that he had ſucceeded in making this combination. His method was by applying the vapors of highly concentrated marine acid to the vapors of ſpirit of wine, by means of a convenient apparatus of veſſels. The detail of this fine experiment may be ſeen in his *Diſſertation on Ether*.

Since his time, an illuſtrious and learned lover of chemiſtry * has found a method of making marine ether with infinitely more facility, and more abundantly, by diſtilling along with ſpirit of wine the *ſmoaking ſpirit of Libavius*, which is nothing more than highly concentrated marine acid, charged with a conſiderable quantity of tin, which it had carried up with it in diſtillation. *See* SPIRIT (SMOAKING) of LIBAVIUS.

M. Pott, in his diſſertation de *acido ſalis vinoſo*, and other chemiſts, mention the mixture of ſome metallic ſalts, containing concentrated marine acid, ſuch as butter of antimony, with ſpirit of wine. The phenomena which accompanied theſe mixtures, ſhewed that theſe ſubſtances re-acted conſiderably on each other, and conſequently were intimately combined.

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* The Marquis de Courtanvaux.

Theſe phenomena, and particularly the eaſy production of marine ether, by the ſmoaking ſpirit of Libavius, prove that the marine acid which has been combined with metallic ſubſtances, is in the fitteſt ſtate for its intimate combination with ſpirit of wine, and for the formation of an ether. Does it acquire this property, by depoſiting along with the metals a portion of ſome of its principles; for inſtance, of its mercurial earth; or by carrying off ſome of the principles of the metals? To me the latter ſeems certainly the method; and that the metallic principle which it carries off is the phlogiſton of the metals. The beſt means of deciding this intereſting queſtion, is to combine the acid with ſeveral metallic ſubſtances, particularly with thoſe which contain much phlogiſton and eaſily part with it, as zinc, regulus of antimony, tin, and iron, and then to ſeparate the acid from theſe ſubſtances; not only to try whether ether can be made by the acid thus prepared, but alſo to aſcertain by the other means which chemiſtry affords, whether the acid be really by this method combined with a portion of the phlogiſton of the metals. Mr. Pott, as well as Stahl, affirms a fact which confirms theſe notions, and which well deſerves to be aſcertained; which is, that the properties of the nitrous acid may be given to the marine by combining the latter with iron. But it is very certain, that the principal difference betwixt theſe two acids, proceeds from the quantity of phlogiſton which enters as a principle into the compoſition of the nitrous. *See* ETHER (MARINE).

The affinities of marine acid, according to Mr. Geoffroy's table, are in the following order: tin, regulus of antimony, copper, ſilver, mercury. According to Mr. Gellert, its affinities are placed thus: phlogiſton, zinc, iron, copper, tin, lead, biſmuth, regulus of antimony, mercury, arſenic. This table ſhews alſo that it does not diſſolve gold, and partly diſſolves ſilver by the dry method. (*m*)

(*m*) The affinity of tin is greater than that of copper to marine acid, according to Mr. Geoffroy's table, and leſs, according to Mr. Gellert's table. I have obſerved that tin readily precipitates copper from this acid, and alſo from aqua regia: Mr. Gellert is therefore miſtaken. The affinities of this, and alſo of other acids to metals, vary in different circumſtances. Thus, for inſtance, although marine acid unites generally with copper or with iron, preferably to mercury, or regulus of antimony; yet if either of theſe latter metallic ſubſtances be added to a mixture of ſea-ſalt and vitriol, green or blue, and conſiderable heat applied, the marine acid of the ſea-ſalt, diſengaged from its baſis by the acid of the vitriol, will not unite with the iron or copper of the vitriol, but with the mercury or regulus of antimony, and along with them will be raiſed by the force of the fire, forming mercury ſublimate, or butter of antimony.

Mr. Hellot found, that by repeatedly drying and diſtilling the mother water of ſea-ſalt, more and more marine acid could be obtained without addition.

Marine acid renders calcareous earths and metals ſoluble in ſpirit of wine; but not volatile alkali, as nitrous acid does; nor fixed alkali, as acetous acid does.

Marine acid, together with burning phlogiſton, gives a reddiſh yellow flame. The marine acid of mercury corroſive ſublimate, combined with copper, forms a fuſible maſs, which kindles like ſulphur, and burns with a blue flame. The phoſphorus of Homberg, which is a combination of the marine acid of ſal ammoniac with calcareous earth, to which a portion of the inflammable principle of the ſal ammoniac adheres, is lumi-

X. ACIDS (MINERAL). Mineral acids are thoſe which are obtained from minerals, or ſubſtances dug from the earth; ſuch as *ſulphur*, *bitumens*, *alum*, *ſelenites*, *vitriols*, *clays*, all which contain *vitriolic acid*; the *nitrous earths*, from which nitrous acid is obtained; and *Sal-gem*, ſea-ſalt, or *common ſalt*, which furniſh marine acid.

There are then three mineral acids, the vitriolic, nitrous, and marine. Theſe acids are generally more ſimple, leſs volatile, more ſuſceptible of concentration, and ſtronger than the acids obtained from animals or vegetables. Hence their power of decompoſing all the neutral ſalts whoſe acids are of the latter kind, of diſengaging theſe acids, and of ſubſtituting themſelves in their place by uniting with the ſubſtance, which together with the animal or vegetable acid had formed the neutral ſalt. *See* ACID, ACID (VITRIOLIC), ACID (NITROUS), ACID (MARINE).

XI. ACID (NITROUS). Nitrous acid has all the general properties of ſaline acid ſubſtances, mentioned under the article Vitriolic Acid. *See* ACID (VITRIOLIC). But it differs from vitriolic acid in the following circumſtances:

1. It is lighter than the vitriolic. The weight of the moſt concentrated nitrous acid, which can be obtained by ordinary means, is to the weight of water as 19 to 12. See a memoir of Mr. Rouelle concerning the inflammation of oils, in the Memoirs of the Academy for the year 1747.

2. It is of a yellowiſh-red flame color.

3. It is leſs fixed than vitriolic acid, and cannot therefore be ever obtained in a concrete form, when unmixed.

4. It perpetually exhales in vapors of the ſame color as itſelf.

5. Its ſmell and taſte are peculiar and diſtinguiſhing.

6. When highly concentrated, it ſtrongly attracts the moiſture of the air, but leſs ſtrongly than vitriolic acid highly concentrated.

7. When concentrated nitrous acid is mixed with water, a conſiderable heat and ebullition are produced from the activity with which theſe two ſubſtances combine. While they are mixing, a ſingular and curious phenomenon appears, which is, that the liquor aſſumes a blue or deep green color, while the vapors continue ſtill of their original yellowiſh red. M. Beaumé has made this obſervation.

This blue color, as the ſame chemiſt has remarked, diſappears in a few days, if the nitrous acid has been diluted with much water.

Concentrated nitrous acid is very corroſive. It tinges the ſkin with a yellow color, which does not diſappear till the epidermis comes off. It is ſucceſsfully employed to corrode and gradually deſtroy warts, and uninflamed, indolent tumors.

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nous when ſtruck in the dark. From theſe facts, together with the preparation of marine ether, we may perceive that marine acid is capable of uniting with phlogiſton, and that a marine ſulphur might probably be formed, if the volatility of marine acid did not prevent the application of heat ſufficient for the forming of that combination.

Homberg found, that marine acid corrodes glaſs more than any other acid. For the proceſs of obtaining marine acid, ſee SPIRIT OF SALT.

If the opinion of Becker, Stahl, Junker, and all the ſcholars of Stahl be true, that there is only one primitive acid, whence the reſt are formed; and that this moſt ſimple acid, the principle of all others, is the vitriolic, then it follows that nitrous acid is nothing elſe than vitriolic acid, changed by the union of ſome other principle. Further, theſe chemiſts think that nitrous acid is formed from the vitriolic combined, by means of the putrid fermentation, with a certain quantity of phlogiſton. To prove their opinion, they give the following reaſons:

1. That the nitrous acid is obtained from nothing elſe than materials impregnated with putrid juices of animal and vegetable ſubſtances, which are known to abound with phlogiſton: whereas vitriolic acid exiſts, not only in moſt minerals, and in the very earths and ſtones, which are fitteſt to form a matrix for the generation of nitrous acid, but alſo in the atmoſphere, as appears from the experiment of expoſing to the air linnen ſoaked in a lixivium of alkaline ſalt, which in a certain time is found to be changed into vitriolated tartar.

2. There is a great analogy betwixt thoſe properties of the nitrous and volatile vitriolic acids, by which each of theſe acids differs from vitriolic acid, and volatile vitriolic acid is evidently vitriolic acid changed by union with phlogiſton.

This volatile vitriolic acid differs from vitriolic acid by its volatility, by its ſmell, by its weaker adheſion to alkaline ſalts, by the greater ſolubility and different form of the cryſtals reſulting from its union with alkaline ſalts.

But theſe properties are the ſame which diſtinguiſh nitrous acid from the vitriolic. Beſides, the volatile vitriolic and nitrous acids reſemble each other, and differ from vitriolic acid in the following reſpects: 1. They produce a much greater alteration on the colors of vegetables than the vitriolic does: and 2. The ſalts formed by their combination with fixed alkali reſemble each other, and are equally different from vitriolated tartar.

Several new intereſting experiments might be made to determine more particularly the analogy betwixt the volatile vitriolic and nitrous acids. The ſalt reſulting from the combination of volatile vitriolic acid and abſorbent earths might be examined, in order to diſcover whether it be deliqueſcent, like the ſalt from the combination of the ſame earth with nitrous acid, and in what other circumſtances theſe two ſalts reſemble each other, and differ from the vitriolic ſalt with earthy baſe, or ſelenites. This inquiry would be ſtill more intereſting, as the nitrous ſalts with earthy baſes have alſo been little examined. *See* SALTS (NITROUS) *with* EARTHY BASES.

Nitrous acid is one of the moſt powerful menſtruums in chemiſtry: not that it is the ſtrongeſt acid; for in ſtrength it is inferior to vitriolic acid, and even in certain circumſtances to marine acid: but on account of the facility, of the quickneſs, and of the activity with which it diſſolves m[illegible] ſubſtances.

The bodies upon which it acts moſt forcibly are, phlogiſton, alkalies fixed and volatile, metallic ſubſtances and earths, particularly of the calcareous and abſorbent kinds.

Nothing can equal the impetuoſity with which nitrous acid joins itſelf to phlogiſton. It is ſo great, that probably nitrous acid has a ſtronger affinity with phlogiſton than the vitriolic has: and it is probable too, that *tin, which the nitrous acid deprives of its phlogiſton, and in ſome ſort calcines rather than diſſolves. See* Tin. *(o).*

XII. ACID (PHOSPHORIC). *See* Phosphorus.

XIII. ACID (VOLATILE SULPHUREOUS, or Volatile Vitriolic). This is nothing elſe than vitriolic acid diluted with water, and weakly united to the inflammable principle. The properties of this acid are then the ſame *eſſentially* as thoſe of vitriolic acid. *See* Acid (Vitriolic). But the phlogiſton which is united with the volatile acid makes it differ conſiderably from the pure vitriolic acid.

It differs from vitriolic acid, 1. By its ſmell, which is ſo active and penetrating, that it can inſtantaneouſly ſuffocate and kill animals. This ſmell is the ſame as that of lighted ſulphur. As vitriolic acid, when pure and free from phlogiſton, has no ſmell, it appears that the ſmell of volatile vitriolic acid is cauſed by its phlogiſton; and this is one of the beſt proofs of the opinion of Stahl and other chemiſts, who think that phlogiſton is the principle of all odors. This opinion will appear even demonſtrated, when we conſider that no odoriferous ſubſtance can be found, in which it is not eaſy to ſhew the preſence of phlogiſton. *See* Phlogiston.

2. The volatile acid differs from the vitriolic by its volatility. The latter is the moſt fixed of the mineral acids, and is for that reaſon the moſt ſuſceptible of concentration: but the volatility of the former is ſo great, that it cannot be much concentrated. This property proves that phlogiſton is a principle eſſentially volatile.

3. The volatile acid is infinitely weaker than vitriolic acid; not only becauſe it cannot be ſo much concentrated, but alſo becauſe by its combination with phlogiſton it is rendered leſs ſimple, and conſequently leſs capable of affinity with other bodies. Therefore, the neutral ſalts formed by it with alkalies, are eaſily decompoſed by vitriolic acid, and alſo by all other acids, even the weakeſt amongſt the vegetable.

4. The neutral ſalt which reſults from the union of volatile vitriolic acid and fixed alkali, differs much from vitriolated tartar with reſpect to the figure of its cryſtals, which are long and needle-like, arranging themſelves together in form of tufts or ſhrubs. Its taſte alſo is different from that of vitriolated tartar, and it is more ſoluble in water: all theſe properties ſhew in a

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(o) Nitrous acid forms with copper, a green, with iron, a reddiſh; with lead, a yellow; and with ſilver, biſmuth, mercury, and zinc, colorleſs ſolutions. Tin it diſſolves imperfectly, and it corrodes regulus of antimony to a white powder. With regulus of cobalt it forms a red, and with nickel a green ſolution. It diſſolves arſenic, and, according to Henckel and Neumann, forms with it a gum-like ſubſtance. Dr. Brandt found that by particular management it can diſſolve gold. *See* Gold. It has little effect on metallic calxes.

Nitrous acid combined with chalk forms the phoſphorus of Baldwin. *See* Phosphoric Stones. Cohobated and diſtilled with quicklime, it emitted an inflammable vapor. *See Mr. Pott's Diſſertation on the Solution of Quicklime by Nitrous Acid.* With ice this acid produces cold remarkably. Concerning the origin of nitrous acid, *see* Nitre *and* Salt; and for the proceſs of obtaining it, *ſee* Spirit *of* Nitre.

neutral ſalt the weak union of its acid and baſe. This ſalt is called the *ſulphureous ſalt of* STAHL. *See* SALT (SULPHUREOUS).

5. The action of volatile vitriolic acid is much more evident than of vitriolic acid upon the colors of vegetables, as appears by pouring an equal quantity of each of the two acids into the tincture of violets, or of heliotrope, of cochenille, Braſil wood, &c. In all theſe inſtances, the tinctures into which volatile vitriolic acid has been poured, will have loſt much more of the intenſity of their colors than the other tinctures; that is to ſay, their colors will be more changed, enlivened, and heightened. This effect is produced to ſuch a degree by this acid, that it deſtroys moſt colors, and makes them diſappear entirely in time. This property renders it very uſeful in ſeveral arts, by giving to certain matters, for inſtance to wools and ſilks, a degree of whiteneſs to which they could not be otherwiſe brought. For this purpoſe, theſe matters are expoſed in a cloſe place to the fumes of burning ſulphur, from which, as we ſhall afterwards ſee, much of this acid exhales. *See* SULPHUR.

Although volatile vitriolic acid differs eſſentially from nitrous acid, ſince the former is nothing elſe than vitriolic acid diſguiſed by the addition of phlogiſton, which is but weakly united to it; nevertheleſs, it is neceſſary to remark, that all the properties now recited of the volatile acid, make it reſemble nitrous acid as much as they diſtinguiſh it from vitriolic acid. From this remark may be drawn one of the ſtrongeſt preſumptions in favor of Stahl's opinion concerning the nature of nitrous acid. This great chemiſt thinks, that vitriolic acid, which he therefore calls the *univerſal acid*, is the principle of all other acids, and the moſt ſimple of all. He thinks that nitrous acid is particularly nothing elſe than vitriolic acid combined by means of putrefaction with a certain quantity of phlogiſton; but in a manner very different, and infinitely more intimately than the phlogiſton is combined in volatile vitriolic acid. For this latter combination is ſo weak, that it is decompoſed by contact of air; ſo that the moſt ſtrong and penetrating volatile vitriolic acid, by expoſure in open veſſels, loſes in a little time all its ſmell and volatility, and becomes entirely ſimilar to a pure and weak vitriolic acid. The ſame phenomenon takes place when the volatile acid is combined with an alkali. Hence the ſulphureous ſalt of Stahl, expoſed for a while to free air, loſes all the properties which diſtinguiſh it from vitriolated tartar, and becomes no wiſe different from it.

The true reaſon of the weakneſs of adheſion of the phlogiſton in volatile vitriolic acid, is the preſence of the aqueous principle, above the quantity of water eſſential to vitriolic acid. This principle always reſiſts a ſtrong and intimate union of phlogiſton with any body.

This is ſo true, that if vitriolic acid deprived of all water except what is eſſential to it, be applied to any matter containing phlogiſton, volatile vitriolic acid is not then produced, but true ſulphur, in which the phlogiſton adheres more ſtrongly. *See* SULPHUR. On the contrary, when a vitriolic acid, overcharged with ſuperfluous water, is combined with a matter containing phlogiſton, volatile vitriolic acid is conſtantly produced, and never ſulphur, except that in the very act of combination the vitriolic acid be deprived of all its ſuper-abundant water.

The great facility which vitriolic acid has to combine with phlogiſton, even when ſuperfluous water is mixed with it, furniſhes many methods of producing abundantly this volatile vitriolic acid.

Stahl propoſes two. The firſt is, by burning ſulphur as ſlowly and gently as poſſible. The acid which exhales in this operation is very volatile, very phlogiſticated, and very ſuffocating; for two reaſons: 1. Becauſe of the little activity with which the ſulphur burns, the inflammable principle is not entirely conſumed, but a portion of it remains united to the acid: and, 2. Becauſe when the vitriolic acid, which in ſulphur is in its higheſt degree of concentration, and even in a ſtate of perfect dryneſs, diſengages itſelf by degrees, during the ſlow burning of the ſulphur; it finds in the air a portion of water which it greedily ſeizes, and which renders it fit to be changed with the remaining phlogiſton into volatile vitriolic acid. When ſulphur is burnt haſtily and ſtrongly, little or no volatile vitriolic acid is produced, principally becauſe then almoſt all the inflammable principle of the ſulphur is deſtroyed by this perfect inflammation.

This firſt method of obtaining the volatile vitriolic acid is the beſt and eaſieſt, when it is not intended to collect it, but to apply it to ſome body as ſoon as it is produced; as, for example, to kill inſects or noxious animals, to whiten wools and ſilks, to ſulphurate wines, or to produce the ſulphureous ſalt of Stahl. *See* SALT (SULPHUREOUS. *See* alſo SULPHUR). But this method is improper for collecting the volatile acid, becauſe ſulphur cannot burn in cloſe veſſels.

The ſecond method propoſed by Stahl for obtaining the volatile vitriolic acid, is by diſtilling green or martial vitriol in a cracked retort, to which a receiver is properly luted. By this method a conſiderable quantity is produced and collected; becauſe, 1. The phlegm of the martial vitriol ſupplies the neceſſary water to the vitriolic acid; and, 2. Enough of the phlogiſton of the burning coals paſſes through the crack of the veſſel, to form volatile vitriolic acid. This method, though very good in itſelf, is ſubject to a very great inconveniency in practice; which is, that when cracked retorts are expoſed to the fire with the greateſt caution, they are very apt to break ſtill more, and entirely to fall in pieces, by which the operation is ſpoiled.

This inconveniency may be avoided by diſtilling in a good retort, not cracked, a mixture of vitriolic acid, or ſubſtance containing it, and any matter capable of furniſhing at once water and phlogiſton. Thus ſpirit of wine, oils, fat, reſins, &c. mixed and diſtilled with vitriolic acid, can always furniſh a good quantity of ſtrong volatile vitriolic acid. *See* OIL and ETHER (VITRIOLIC).

This acid ought to be kept in cryſtal glaſs bottles, cloſed exactly with glaſs ſtoppers; and to be as little as poſſible expoſed to air, becauſe vapors always exhale from it when ſo expoſed, by which its ſtrength is impaired from the diſſipation of part of its phlogiſton.

This great facility which the phlogiſton has to ſeparate itſelf from volatile vitriolic acid, is the cauſe of the exceeding difficulty, and even impoſſibility of determining preciſely the quantity of phlogiſton neceſſary to convert any given quantity of vitriolic acid into volatile vitriolic acid. In general, we know that very little is required; a ſingle drop of oil being capable of converting, by diſtillation, a large quantity of vitriolic acid into very ſtrong volatile acid.

It is no leſs difficult to determine certainly and preciſely the properties of this acid as a menſtruum of different ſubſtances; as, for example, earths and metals. This difficulty alſo proceeds from the facility with which it parts with its phlogiſton, and conſequently changes its nature, which it does more or leſs in the act of combination with the ſubſtances it diſſolves. It is an acid perpetually changing, and which we cannot be certain of having the ſame at different times.

Theſe difficulties ought not to prevent trials of ſuch combinations, hitherto little known. Becauſe in an important and eſſential enquiry, which may throw new light upon the theory of acids and phlogiſton, even approximations become important and eſſential.

XIV. ACID (TARTAREOUS). *See* TARTAR, and CREAM of TARTAR.

XV. ACIDS (VEGETABLE). All acids obtained from vegetable matters are ſo called. Such are the juices of ſour fruits, wine turned ſour, or vinegar; cryſtals of tartar; all the eſſential, acid, concrete ſalts, procured by cryſtalliſation from the expreſſed juices of plants; and laſtly, all the acids obtained from vegetable ſubſtances in analyſing them by diſtillation.

Theſe acids differ from mineral acids in being leſs ſimple, leſs fixed, leſs ſuſceptible of concentration and weaker; qualities, which proceed from their union to a certain quantity of oil, with which they are ſo intimately combined, that they cannot be ſeparated from it but by very nice and ſtudied operations. Hence all the neutral ſalts formed by theſe acids may be decompoſed, either by the mere action of the fire, or by any mineral acid whatever.

The particulars of what is here advanced in general on their properties and principles, may be ſeen under the articles of the principal vegetable acids.

XVI. ACID (VITRIOLIC) was ſo named, becauſe, formerly, it was chiefly obtained from martial vitriol. It is, according to the very probable opinion of Becker and of Stahl, the ſimpleſt of all acids, and conſequently the ſimpleſt of all ſaline ſubſtances. When it is as pure as can be obtained, it is entirely free from ſmell and color; that is to ſay, in theſe reſpects, it reſembles water.

It poſſeſſes moſt eminently all the properties characteriſing ſaline, and particularly acid ſubſtances.

It taſtes exceedingly ſour, and it ſets the teeth on edge.

It changes to red the color of ſyrup of violets, of tincture of heliotropium, &c.

It is very ſuſceptible of concentration; that is, much of the water unneceſſary to its ſaline eſſence may be raiſed by diſtillation. *See* CONCENTRATION.

The ſpecific gravity of this acid, when much concentrated, is very great. It is more than double the ſpecific gravity of water, ſometimes as 17 to 8, and perhaps might be further concentrated. M. Hellot, in puſhing ſtrongly the diſtillation of martial vitriol, obtained towards the end of the operation a vitriolic acid ſo concentrated, that it was ſolid and cryſtalline. Some chemiſts have given to vitriolic acid ſo concentrated as to become concrete, the name of GLACIAL, or ICY OIL of VITRIOL.

Vitriolic acid highly concentrated is leſs fluid than water. It pours ropey like oil, and feels to the fingers greaſy. Theſe two laſt properties have occaſioned [illegible] the ancient chemiſts to call it *Oil of Vitriol.* This name is very improper, ſince it is not inflammable, nor has any peculiar properties of oils. *See* OILS. Its oily conſiſtence is owing to the great approximation of its parts, and its apparent unctuoſity proceeds from the ſame cauſe; joined to this, that as it is a very powerful diſſolvent, it attacks and diſſolves effectually a portion of the unctuous ſubſtance of the ſkin which it touches.

The very ſtrong and concentrated vitriolic acid is not only much heavier, but alſo much more fixed than water. Hence it is capable of receiving, when expoſed to fire, a degree of heat greatly ſuperior to that of boiling water, and which almoſt amounts to a red heat.

This acid when well concentrated, (which we ſuppoſe here all along) unites itſelf to water with an aſtoniſhing activity and impetuoſity. If two or three ounces of it be mixed with as much pure and cold water, the re-action of theſe two ſubſtances on each other is ſo ſtrong, that inſtantly a boiling ariſes, attended with many vapors, and a noiſe ſimilar to that of a red-hot iron plunged into water. The heat reſulting from the re-action of theſe two cold liquors is ſo great, that in an inſtant it equals, and even much ſurpaſſes the heat of boiling water. Some chemiſts have attributed this heat to a diſengagement of the igneous particles contained in vitriolic acid. This is not true, except they only mean the igneous particles contained in this acid, as in all other ſubſtances, and which are ſet in motion by all colliſions; but not any ſuperabundant igneous particles peculiar to this acid, ſince no experiment demonſtrates their exiſtence.

The concentrated vitriolic acid, expoſed to the atmoſphere, attracts moiſture ſo much, that its bulk is conſiderably encreaſed, and it becomes mixed with twice its weight of water. (*p*)

It may be combined with the inflammable principle or phlogiſton, and thereby form two compounds, differing from each other in the quantity of phlogiſton, and in the cloſeneſs of the union.

The firſt, which is the reſult of a combination of weak vitriolic acid with a ſmall quantity of phlogiſton, is called volatile, ſulphureous, or vitriolic acid. *See* ACID (SULPHUREOUS); and the ſecond, which ariſes from an intimate union of vitriolic acid, freed from all water above what is neceſſary to its eſſence as a ſaline ſubſtance, with about a ſeventh part of its weight of pure phlogiſton, is called *Sulphur. See* SULPHUR.

Earths are more or leſs ſoluble by vitriolic acid, according to their natures; and form with it different ſalts, or earthy ſaline compounds of different properties, according to the kinds of earths employed. Particular management is requiſite to combine vitrifiable earths with vitriolic acid: and the ſalts reſulting

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(*p*) Dr. Gould relates, that three drams of concentrated vitriolic acid acquired by imbibing moiſture from the air, in 57 days, an increaſe of ſix drams and a half; and that in general this acid acquires increaſe of weight in a compound ratio of the largeneſs of the ſurface expoſed, and of the humidity of the atmoſphere. Neuman found that an ounce of this acid, by expoſure to air during a year, had imbibed more moiſture than ſix times its original weight. For the method of obtaining this acid, *ſee* SPIRIT *of* SULPHUR, CLYSSUS *of* SULPHUR, and CONCENTRATION *of* VITRIOLIC ACID.

from their combination have not yet been ſufficiently examined. *See* VITRIFIABLE EARTHS and LIQUOR of FLINTS.

Calcareous earths may be diſſolved without any previous preparation by vitriolic acid. This ſolution is made with moderate efferveſcence; and from this combination reſults an earthy ſaline compound, ſuſceptible of cryſtallization, whoſe principles are ſo intimately combined, that the ſaline properties of the vitriolic acid are almoſt entirely maſked by thoſe of the earth which is the prevailing principle (*ſee* AFFINITY); ſo that this neutral vitriolic ſalt with earthy baſis has no ſenſible taſte, and is ſcarcely ſoluble in water: according to Mr. Baumé's experiment, one grain only of it could be diſſolved in an ounce of water. This want of ſaline properties, which appears common to all vitriolic ſalts with baſes of calcareous earth, has occaſioned them to be diſtinguiſhed by the name of *Selenites*, from other combinations whoſe ſaline properties are more obvious. *See* SELENITES.

Alum is a vitriolic ſalt with earthy baſis, but it differs conſiderably from Selenites. This difference proceeds from the nature of its earthy baſis, which is not calcareous, but argillaceous. *See* ALUM.

Vitriolic acid may be combined and ſaturated with vegetable fixed alkali: and from this combination is formed a neutral ſalt, capable of being cryſtallized, bitter, hard, and not eaſily ſoluble in water. Several names have been given to this ſalt from the ſeveral ſubſtances whence its alkaline baſis was extracted, at a time when theſe alkalies were ſuppoſed to differ from each other. Theſe names are, *Sal de duobus*; *vitriolated tartar*; *arcanum duplicatum*. *See theſe words*, and ALKALI (VEGETABLE.)

With the alkaline baſis of ſea ſalt, called marine or foſſil alkali, the vitriolic acid forms a neutral, cryſtalizable ſalt, called *Glauber's ſalt*, which differs from vitriolated tartar in the figure of its cryſtals, its greater ſolubility in water, the quantity of water contained in its cryſtals, and its property of drying in the air, or loſing much of its water, by which the cryſtals loſe their tranſparency, their ſolidity, and are reduced into a white meal, called *effloreſcence*. *See* ALKALI (MARINE), and SALT *of* GLAUBER.

Volatile alkali combined to the point of ſaturation with a vitriolic acid, forms a neutral ammoniacal ſalt, and cryſtalizable, called *Salt (Vitriolic Ammoniac)*, *which ſee*, and ALKALI (VOLATILE).

Vitriolic acid being more ſimple and more powerful than the nitrous and marine acids, ſeparates them from the alkalies to which they are united, and ſubſtitutes itſelf in their place. *See* NITRE and SALT (COMMON).

In general, this acid acts upon all metallic ſubſtances, and diſſolves them with phenomena peculiar to each. It forms with them neutral ſalts with metallic baſes capable of cryſtalizing; to all which ſalts M. Macquer thinks proper in his courſe of chemiſtry to give the general name of *vitriol*, and to ſpecify the different vitriols by the name of the metallic matters which enter into their compoſition. Thus, for example, he propoſes to call the combination of vitriolic acid with ſilver, *vitriol of ſilver*, or *lunar vitriol*; and the combination of the ſame acid with mercury, *vitriol of mercury*, &c. in the ſame manner as the neutral metallic ſalts formed by the union of vitriolic acid with iron and with copper, are called *vitriol of copper*, and *vitriol of iron*, or *martial vitriol*. *See* VITRIOL.

This acid, in conſequence of its great affinity with the inflammable principle, attacks the phlogiſton of metals when it diſſolves them, and ſeparates part of it from thoſe which are capable of being deprived of it; conſequently it calcines them more or leſs according to their nature, and to the manner of making the ſolution, and adheres to them proportionably leſs, as it has taken from them a greater quantity of their phlogiſton. We may conclude from theſe phenomena, that vitriolic acid diſſolves metals chiefly by means of their phlogiſton; or that this principle is a medium of union between this acid and metallic earths.

The moſt general phenomena accompanying the ſolutions of metallic matters in vitriolic acid by the humid method, are, 1. The effervescence and heat, which are commonly moderate. 2. The vapors; many of which are the volatile vitriolic acid, as in the ſolution of mercury; or they are inflammable vapors, as in the ſolution of iron. 3. The formation of concrete ſulphur, as in the ſolution of tin. See *the particular details of all theſe ſolutions of metallic matters by vitriolic acid, under the article of each metallic ſubſtance, and at the word* VITRIOL. (*q*)

It appears from what has been ſaid on the combinations of vitriolic acid with all the ſubſtances with which it can form a neutral ſalt, that all theſe neutral vitriolic ſalts are ſuſceptible of cryſtallization. This property is peculiar to vitriolic acid, and probably proceeds from the intimacy of union contracted betwixt this acid and the ſubſtances which it diſſolves.

Concentrated vitriolic acid acts with conſiderable force on all oils and concrete oily matters. It boils and grows warm when added to them. It partly

decompoſed

(*q*) Diluted vitriolic acid diſſolves iron and zinc ſpeedily, and copper very ſlowly. Boiling concentrated vitriolic acid diſſolves copper, and partly diſſolves and partly corrodes ſilver, tin, mercury, and lead. Vitriolic acid does not directly diſſolve gold, but precipitates it from aqua regia, which precipitate is ſoluble in vitriolic acid. It leſſens the volatility of mercury and of arſenic; and the fuſibility of lead, zinc, biſmuth, and regulus of antimony. It diſſolves the calxes of moſt metals. It alſo diſſolves the ſemimetal, regulus of cobalt, but not nickel.

Although vitriolic acid has a ſtrong power to combine with iron, yet its adheſion to it when diſſolved ſeems to be very weak. Thus Mr. Margraaf found, that by boiling a ſolution of green vitriol in a copper veſſel, or with filings of copper, part of the iron was depoſited, and in its place part of the copper was diſſolved. This experiment is ſo much more remarkable, as a diluted vitriolic acid has no ſenſible effect upon copper in a ſhort time. The acid therefore by its previous ſolution of iron ſeems to have been ſo changed, as to be rendered capable of diſſolving copper. This experiment does not contradict the general rule by which the power of union of vitriolic acid is affirmed to be greater to iron than to copper, but may be explained from the ſlight adheſion of the inflammable principle to the earth of iron; by which property ſalts formed by this metal with vitriolic or nitrous acids are continually decompoſing; the phlogiſton, which is the medium of union betwixt acids and earths, eſcaping into the air or combining with the acid, and the calx of iron ſeparating from the acid, in form of a red ſediment. This decompoſition of martial vitriol, and martial nitre, and alſo of ſome other metallic ſalts ſubject to the ſame change, is accelerated by application of heat, air, moiſture, and, as Mr. Margraaf's experiment ſeems to indicate, by the application of another metal, as copper. Mr. Margraaf has not given his ſentiments concerning the cauſe of the alteration produced upon the acid in his experiment, by which it is rendered capable of diſſolving copper. Is it by abſorption of the phlogiſton of the iron, that it becomes volatile vitriolic acid, and thereby acquires new properties as a menſtruum?

decompoſes them, blackens, and in ſome ſort burns them. From theſe mixtures many fumes exhale, which have a mixt ſmell of burnt oil, and very ſuffocating volatile vitriolic acid. See the detail and explanation of theſe phenomena at the word OIL.

Vitriolic acid, when very weak, does not appear to have any action upon oils, becauſe its ſuperfluous water, with which it ſtrongly adheres, hinders it from combining with theſe ſubſtances, to which the water cannot be united. However, the union of ſuch a weak vitriolic acid with oil, does not ſeem impoſſible. *See* OIL.

Concentrated vitriolic acid ſhews, when mixed with ſpirit of wine, many very intereſting phenomena, and which vary according to the proportions of theſe two acids, and the management employed.

Without diſtillation, it entirely combines in ſubſtance with ſpirit of wine, without occaſioning any decompoſition; that is to ſay, it does not combine with any of the principles of the ſpirit of wine preferably to the reſt. It loſes its acidity by this union, and is rendered greatly milder. Hence it is called *Dulcified Vitriolic Acid.* It has alſo been called WATER of RABEL; which *ſee.*

When ſpirit of wine and vitriolic acid are diſtilled together, the latter decompoſes the former, takes poſſeſſion of its aqueous principle, reduces a part of it into a middle ſubſtance betwixt ardent ſpirits and oil, to which the name *Ether* has been given; and laſtly, the acid reduces the ſpirit of wine into a true oil, which has been improperly called *Sweet Oil of Vitriol. See* the words SPIRIT (ARDENT); ETHER; ETHER (VITRIOLIC); and SWEET OIL *of* VITRIOL.

Vitriolic acid is no where in nature found pure; that is, unmixed with any other matter. This proceeds from its capacity to diſſolve, and to combine with a great variety of different ſubſtances.

Thus vitriolic acid is found naturally combined, 1. With an inflammable ſubſtance; then it is in form of ſulphur or bitumen; or, 2. With earthy ſubſtances in form of ſelenites, aluminous and argillaceous matters; or, 3. With metallic ſubſtances, in form of natural vitriols; or, 4. With alkaline ſalts, in form of neutral vitriolic ſalts with alkaline baſes. But it is almoſt only with the foſſile or marine alkali that the vitriolic acid is ever found naturally combined, becauſe this alkali is moſt generally diffuſed, and is indeed almoſt the only natural alkali. Vitriolic acid is therefore found in form of Glauber's ſalt. Natural Glauber's ſalt is chiefly found in thoſe waters which contain common ſalt. *See* SALT (COMMON) and WATERS *of* SALT FOUNTAINS.

Vitriolic acid, combined with vegetable fixed alkali, forming vitriolated tartar; or with volatile alkali, forming vitriolic ammoniac ſalt, otherwiſe called the ſecret ammoniac ſalt of Glauber; can be found but very rarely, and by particular decompoſitions and combinations; as, for example, by burnings.

From what has been ſaid concerning the ſtates in which vitriolic acid is naturally and habitually found, we may perceive that it cannot be obtained alone and pure without particular artful operations; that is, by decompoſing thoſe bodies which contain moſt of it, and from which it may be eaſieſt procured. Theſe bodies are *Sulphur* and *Vitriols. See theſe words for the extraction of Vitriolic Acid.*

Upon conſidering the ſeveral ſubſtances with which vitriolic acid is found naturally combined, an intereſting queſtion ariſes concerning the original and primitive ſtate of this acid. For as ſulphur is ſpread in very large quantities within the earth, and that by its burning or decompoſition, its acid ſeparated from its phlogiſton becomes capable of combination with earthy and metallic ſubſtances, as happens actually in the fabrication of vitriols and of alum; we may conſider whether all vitriolic acid has been originally in the ſtate of ſulphur; and if one part of this ſulphur being conſumed or decompoſed by natural cauſes, as happens in volcanos, its acid has formed all the vitriols and vitriolic ſalts with earthy baſes, which are found formed in the earth; or whether, as we know by the experiment of the artificial compoſition of ſulphur, that vitriolic acid quits every other ſubſtance in order to combine with phlogiſton; all this acid was originally combined with earthy and metallic ſubſtances; and theſe vitriolic ſalts, meeting matters abounding in phlogiſton, have been decompoſed to form all the ſulphur found in the earth. This queſtion cannot certainly be decided but by the profoundeſt reſearches into the natural hiſtory of theſe ſeveral bodies.

The affinities of vitriolic acid according to Mr. Geoffroy's table are, phlogiſton, fixed alkali, volatile alkali, earths, iron, copper, and ſilver: and according to Mr. Gellert's table, phlogiſton, fixed alkali, volatile alkali, earths, zinc, iron, copper, ſilver, tin, lead, mercury, biſmuth, regulus of antimony, and arſenic.

XVII. ACIDS (VOLATILE). Thoſe acids are ſo called which are more volatile than moſt other acids; which volatility proceeds either from an union of ſome phlogiſton, or of ſome attenuated oil. Such are the volatile vitriolic acid; the acid ſpirits of ſome acrid vegetables, as the roots of ſquills, according to Mr. Cartheuſer; the acids which riſe when butter or fat are diſtilled; and others ſimilar.

XVIII. ADEPT is the name aſſumed by thoſe alchemiſts who pretended to have diſcovered the philoſopher's ſtone. *See* STONE (PHILOSOPHER'S).

XIX. ADOPTER. *See* RECEIVER.

XX. AFFINITY. By affinity (r) is underſtood that tendency which the conſtituent or integrant parts of bodies have to unite, and that power by which they adhere when united.

The definition of affinity ſhews that it is not a word void of meaning. The power with which the parts of bodies tend to unite with each other, and their adheſion when united, are very ſenſible and palpable effects, ſince this power cannot be deſtroyed but by another power as real and more conſiderable. It is

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(r) By the terms *affinity* and *elective attraction*, we ought to underſtand the power by which the conſtituent parts of bodies unite, and not to ſuppoſe that this power is exerted by any ſimilarity and homogeneity of parts, or by any mechanical traction, as theſe terms ſeem to imply. The cauſe of this power, or the manner in which this union of conſtituent parts, is produced, is unknown to us. To theſe terms, therefore, another leſs exceptionable, namely, *the power of combination*, may be ſubſtituted. In our author's definition of affinity is comprehended not only the power of union of the conſtituent parts of bodies, which is the proper object of chemiſtry, but alſo the power of union of the integrant parts of bodies, which he calls the affinity of aggregation, and which is treated of by writers on natural philoſophy and mechanics under the terms

attraction,

beſides demonſtrated by numberleſs experiments; as, for example, by the adheſion of two bodies applied to each other, whoſe ſurfaces are finely poliſhed; by the tendency which two drops of water, or of oil, mercury, or of any other fluid, have to run together and unite into one maſs; by the convex or ſpherical figure which drops of fluids aſſume, when their form is not given them by containing veſſels or other body, and when they are ſupported by bodies with which they are not diſpoſed to unite: all which effects happen even in a vacuum, and demonſtrate the affinity which the integrant parts of bodies ſolid, or fluid, have to each other.

The affinity of the conſtituent parts or principles is demonſtrated by the detail of all the phenomena in chemiſtry.

We do not here enquire into the cauſe of this great effect, which is ſo general, that it may itſelf be conſidered as the cauſe of all combinations, and may ſerve to explain them. It may perhaps be a property as eſſential to matter as its extent and impenetrability, of which we can ſay no more, than that ſuch properties do exiſt. On this ſubject the works of Newton, Freind, Keil, and the Abbé Marcuzzi, may be conſulted. Theſe authors have endeavored to illuſtrate theſe obſcure ſubjects by calculation. We ſhall be ſatisfied with obſerving the moſt remarkable laws, according to which the principles of bodies unite and combine, in conſequence of this property.

M. Macquer diſtinguiſhes ſeveral ſorts of affinities. Not that he believes there are diſtinct ſpecies of affinities; for it is very certain, that it is but one and the ſame property of matter, differently modified according to different circumſtances; but only that he may better diſtinguiſh and remark the phenomena occaſioned by this property, in the detail of the combinations and ſeparations which it effects in the moſt-general and moſt important operations of chemiſtry.

By *ſimple affinity* he means the diſpoſition to unite and adhere, which is obſerved between the integrant and homogeneous parts of the ſame body, or between the heterogeneous parts of two different bodies. The ſimple affinity is therefore diſtinguiſhed into two kinds.

The firſt kind of ſimple affinity produces the *union of aggregation*; that is to ſay, that the body reſulting from this union is of the ſame nature, but of larger ſize. M. Macquer calls it the *affinity of aggregation*; as, for example, when ſeveral looſe particles of the ſame metal or of the ſame earth are united together by fuſion, ſo as to form but one maſs. *See* AGGREGATION.

The ſecond kind of ſimple affinity, producing the union and adherence of heterogeneous parts, different in their natures, from which reſults a new compound body, whoſe properties are different from thoſe of the two principles

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attraction, gravitation, and coheſion. Whether theſe two unions are produced from the ſame cauſe differently modified, as our author affirms, I know not; but their effects are ſo different, that they deſerve to be conſidered *ſeparately*: the union of integrant parts being only an appoſition of theſe parts, which are capable of being disjoined by mechanical means, and without any change produced upon their properties; and the union of conſtituent parts, or combination, being attended with conſiderable changes of properties, and being incapable of disjunction by mechanical means. *See the article* COMPOSITION *of* BODIES, and the following *Note*.

from which it was formed, is called *affinity of compoſition*; becauſe a new body is actually compoſed. If, for example, the primitive integrant parts of vitriolic acid be united with thoſe of iron, a new body reſults from this union, which is neither vitriolic acid nor iron, but a compound of the two, called *martial vitriol*.

The following remarks may be made on ſimple affinities.

1. That the affinity of aggregation reſiſts the affinity of compoſition. For it is evident that the force which makes the homogeneous and integrant parts of a body adhere together, hinders them from ſeparating, in order to join the parts of another body.

2. Hence it follows, that if the adheſion of aggregation between the integrant parts of a body be weakened or deſtroyed, the affinity of compoſition is thereby facilitated; that is, the affinity which they have to join the parts of another body.

3. That as the hardneſs of a body ſuppoſed ſimple and homogeneous depends only on the adheſion of aggregation betwixt its integrant parts, if this adheſion be deſtroyed by ſeparating theſe parts from each other; as by reducing them into fine powder, or ſtill more by diffuſing them in a liquid, with which they have no adheſion, or leſs than they had to each other; they may then be combined with the parts of another body, more or leſs eaſily, in proportion as they have been more or leſs ſeparated by this mechanical diviſion.

4. As different bodies are more or leſs ſuſceptible of this mechanical diviſion, whether artificial or natural, by which their integrant parts are more or leſs ſeparated from each other, hence ariſes a great difference betwixt theſe bodies in their greater or leſs facility of combining with other bodies.

5. This facility of combining with another body does not, however, determine ſolely the degree of affinity betwixt theſe two bodies. For experience ſhews that principles or conſtituent parts of certain compounds, which unite together very readily and eaſily, have however but a weak adheſion, which is deſtroyed by the ſmalleſt effort of analyſis, or chemical decompoſition; while other principles which can be united only with great difficulty, and by ſtudied means, contract together an union much ſtronger, and much leſs apt to be diſſolved. Mercury, for inſtance, unites much more eaſily with nitrous acid than with the marine, but yet it adheres much more ſtrongly to the latter than to the former.

Hence we ought to conclude, that we cannot poſitively determine that one body has no affinity with another body, becauſe no means are known of uniting them. On the contrary, it appears certain that all natural bodies have a certain degree of affinity, and facility of uniting with each other, and a certain degree of adheſion when they are united, and conſequently, that there are no combinations really and abſolutely impoſſible; but that this degree of affinity varies according to the different ſtates in which theſe bodies are found.

However, as the want of union betwixt two bodies prevents their affinity from ſhewing itſelf, we may conſider bodies which we cannot combine as having no affinity together, until chemiſtry be ſo far advanced as to make combinations which now ſeem impoſſible. Thus, for inſtance, oil is ſaid to have no affinity with water, nor lead with iron, nor iron with mercury; becauſe, in fact, theſe bodies cannot be directly united together in chemical operations. Thus any affinity which they may have together is to us of no conſequence.

On the contrary, as the affinities of bodies which may be united together, produce in chemical operations effects proportionable to their facility of union, and to their force of adheſion when united, we may conſider the affinity of bodies in general, as being in a compound ratio of theſe two properties.

The laſt remark we can make on the ſimple affinity of compoſition, furniſhes a very uſeful and very general fundamental law, by which we may diſcover, even without decompoſition, the principles of which bodies are compoſed. The remark is, that all compound bodies have properties partaking of the properties of the principles of which theſe bodies are compoſed. Thus, for example, the union of two principles, of which one is fixed, and the other is volatile, forms a compound, whoſe degree of fixity or volatility is intermediate betwixt thoſe of the two principles.

The ſame may be ſaid of all the other properties; ſuch as gravity, opacity, tranſparency, ductility, hardneſs, fluidity, &c. and even of the affinities: ſo that, ſuppoſing we knew perfectly the properties of the principles of a compound, we might by examining the properties of this compound, diſcover its principles, even although its analyſis were impoſſible.

We muſt however allow that this rule, although very general, is ſubject to a conſiderable number of reſtrictions and modifications, which depend on a number of particular circumſtances. For example: it happens ſometimes that the operation by which two principles are united changes or even annuls ſome of the properties of theſe principles: it happens too that ſometimes their union developes new properties, which cannot be immediately perceived in either of the principles. But ſuch changes are never ſo compleat as to lead one into groſs miſtakes concerning the principles; therefore they do not prevent the rule from being ſufficiently general, to be an excellent guide in many chemical enquiries. (s)

Where more than two bodies act upon one another, the *affinity* may be called *complicated*; and from the definition given, it appears that all theſe complicated affinities muſt be of the kind called *Affinity of Compoſition*.

(s) The rule mentioned in the text is ſo far from being general, that perhaps the reverſe of it may be conſidered as a general rule; and a change of properties, and a production of new properties, may be conſidered as criterions, by which compound bodies, chemically combined, may be diſtinguiſhed from bodies formed merely by mixture or appoſition of integrant parts; in which latter compound bodies, the properties are intermediate betwixt the properties of the ſeveral component parts, and no new properties are produced. Thus, three parts of copper combined by fuſion with one part of tin, forms a body more hard, more brittle, and more ſonorous, than either of the conſtituent metals. Its hardneſs, therefore, its brittleneſs, and its ſonorouſneſs may be conſidered as new properties. Its color is much whiter than the intermediate color, and its ſpecific gravity is greater than the intermediate ſpecific gravity. Further, the properties of bodies are in many inſtances deſtroyed or annulled by chemical combination. Thus the acrimony and deliqueſcency of acids and of alkalies are almoſt entirely annulled by combining theſe two kinds of ſubſtances together. Every body chemically combined may furniſh facts which refute the general propoſition mentioned in the text. Bodies formed by mixing, not by chemically combining ſeveral ſubſtances together; as, for inſtance, a liquor formed by mixing wine and water; partake of the qualities of each ingredient, proportionably to the quantity of it employed. *See* COMPOSITION *of* BODIES, *and* AGGREGATION.

Firſt, we ought to conſider that complicated affinity in which only three principles act. Experience indicates the following obſervations.

If a principle be added to two other principles united together, phenomena of compoſition or of decompoſition happen, which differ according to the affinities of theſe three bodies to each other.

1. Sometimes the third ſupervening principle is united to the other two, and forms together with them a compound conſiſting of three principles. For example, if to a maſs compoſed of gold and ſilver, ſome copper be added, this third metal is united to the other two, and forms with them a compound conſiſting of three principles, namely, gold, ſilver, and copper. Thus it happens, when the third ſupervening principle has with the two others an affinity equal, or almoſt equal to the affinity which theſe two principles have to each other.

2. The ſame thing alſo happens ſometimes, although the third ſupervening principle has no affinity with one of the two principles originally united. But then it is neceſſary that this ſupervening principle ſhould have, with the other of the two principles, an affinity equal to the affinity ſubſiſting between thoſe two principles originally united. And in this caſe, that principle which ſerves to connect and unite the two which could not otherwiſe be united, is called an *intermedium*. This affinity may alſo be called the *affinity of intermediums*. For example, if water be added to the compound called *liver of ſulphur*, which conſiſts of two principles, ſulphur and fixed alkali, it unites with the water, diſſolves in it without being decompoſed, and forms a new compound conſiſting of three principles, namely, ſulphur, fixed alkali, and water. The water and ſulphur could not by themſelves form any union: but as fixed alkali has a great affinity with both ſulphur and water, it ſerves upon this occaſion as an intermedium to unite theſe two ſubſtances together. It is neceſſary to remark, that in this affinity of intermediums, the affinity of the principle which ſerves as an intermedium is weakened, becauſe it is divided betwixt two bodies; and that the union contracted with them is leſs ſtrong than if it were united to one of them only.

3. Sometimes a third principle, when added to a compound conſiſting of two principles, does not unite but with one of theſe two principles, and obliges the other to ſeparate itſelf entirely from the principle with which it was originally united. In this caſe a total decompoſition happens of the firſt compound, and a new combination of the remaining principle with the ſupervening principle; from which a new compound reſults. This happens when the ſupervening principle has little or no affinity with one of the principles of the compound; and when it has with the other, an affinity much ſtronger than that which ſubſiſts betwixt the two firſt principles. For example, when an alkali is added to a ſolution of a metallic matter in an acid, as it has more affinity with the acid than with the metal, it ſeizes the acid, and obliges it to quit the metal, which therefore precipitates; becauſe the metal has much leſs affinity than the alkaline ſalt has to the acid.

4. It happens ſometimes that a principle, which, in conſequence of the affinity we have been diſcourſing of, has been ſeparated from another principle, may again reſume its place with the principle, as it was originally, and diſpoſſeſs the ſupervening principle. This affinity, which is called *reciprocal*, on account

of its reciprocal effects, takes place when the two principles which are alternately ſeparated from the third principle by each other, have with this third principle, an almoſt equal affinity, and that their ſeparation is procured by particular circumſtances relative to ſome of their properties.

All that has been ſaid concerning the affinities of three principles may be applied to affinities of four principles, due regard being had to the changes produced by the introduction of a fourth principle. It is evident, for example, that in place of one decompoſition and one new compoſition, which can reſult from the different degrees of affinity of three principles, the affinities of four principles forming two new compounds, may, by a mutual change, produce two decompoſitions and two new combinations. This always happens when the ſum of the affinities, which each of the principles of the two compounds has with the principles of the other, ſurpaſſes the ſum of the affinities ſubſiſting betwixt the principles forming the two firſt compounds. This ſort of affinity, where there is a double exchange of principles, may be called *double affinity*. Examples of theſe affinities are often met in chemical operations and mixtures; and without a knowledge of them, it would be impoſſible to explain many ſingular phenomena of decompoſition. For example, it happens often that two principles, neither of which could ſingly effect the diſunion of the principles of a compound, becauſe their affinities are each of them inferior to the affinity betwixt the principles of that compound, become nevertheleſs capable of procuring this decompoſition when they act in concurrence. For this purpoſe, it is ſufficient, as we have already ſaid, that the ſum of affinities which the two decompoſing principles have with the principles of the body to be decompoſed, ſhould ſurpaſs the ſum of the affinity betwixt the principles of the decompoſing body, and the affinity betwixt the principles of the body to be decompoſed. See examples of this play of affinities at the words BLUE (PRUSSIAN), and SALT (NEUTRAL ARSENICAL).

We ſhall purſue no farther theſe remarks upon affinities; becauſe the affinities of bodies compounded of many principles are much leſs ſtrong and leſs ſenſible in chemical operations; or becauſe this ſcience is not yet ſufficiently advanced to have obſerved and diſtinguiſhed them all. What we have ſaid is ſufficient to form juſt ideas on the theory of all the important phenomena which are exhibited by the fundamental experiments, and to conduct to many new diſcoveries.

XXI. AGARIC. (t)

XXII. AGATE. (u)

(t) AGARIC is a fungus growing on the trunk of the common larch tree, from which turpentine is obtained. Three-fourths of it is a reſinous ſubſtance, and the remainder is a ſlimy mucilaginous earthy matter, ſo tenacious as ſcarcely by any method to be diſſolved by water.

(u) AGATE is a flint variegated with different colors blended together, and ſometimes with colored lines and dendritical figures, as the *mocha ſtone*, which is a variety of agate, or with red ſpots, as the *ſardea* or *St. Stephen's gem*, which alſo are varieties of this ſtone. For the chemical properties of agates, *ſee* EARTHS (VITRIFIABLE). By fire the *color* of a white agate, called *chalcedony*, was rendered whiter, and the color of a black agate was not changed. Colors may be given to agates, or their natural colors may be changed. Mr. du Fay, in the Memoirs of the Academy of Sciences, 1728, relates, that to chalcedony a ſaturated ſolution of ſilver in ſtrong ſpirit of

XXIII. AGGREGATION. In order to have a clear idea of what chemiſts mean by the words *aggregation*, *aggregate*, *aggregated bodies*, we muſt attend to the difference betwixt what natural philoſophers call *conſtituent parts* and *integrant parts* of bodies. The conſtituent parts are, properly ſpeaking, the principles of bodies. Theſe are ſubſtances differing in nature from each other, which, by their union and mutual combination, really *conſtitute* mixed bodies, which partake of the properties of their conſtituent parts. For example, the conſtituent parts of common ſalt are an acid and an alkali, which ought to be conſidered as the principles of this ſalt. at leaſt as its proximate principles. *See* Principles. As this acid and alkali are what really conſtitute common ſalt, and are the parts, to the union of which it owes its exiſtence and properties, it is evident that the conſtituent parts cannot be diſunited from each other, without deſtroying and decompoſing it: ſo that after ſuch a diſunion, the ſalt will no longer exiſt, but only the acid and the alkali of the ſalt, which are very different from the ſalt, and from each other.

On the contrary, the *integrant parts* of bodies do not abſolutely differ from each other; nor do they differ, as to the nature and principles, from the body into whoſe maſs they enter. By the integrant parts of a body are to be underſtood the ſmalleſt molecules or particles into which this body can be reduced without decompoſition. We may conceive that a neutral ſalt, for inſtance, common ſalt, may be divided into molecules ſtill ſmaller and ſmaller, without any ſeparation of the acid and alkali which conſtitute the ſalt; ſo that theſe molecules, however ſmall, ſhall always be common ſalt, and poſſeſſed of all its eſſential properties. If we ſhould now ſuppoſe that theſe molecules are arrived at their utmoſt degree of ſmallneſs, ſo that each of them ſhall be compoſed of one atom of acid and of another atom of alkali, and that they cannot be further divided without a ſeparation of the acid and alkali, then theſe laſt molecules are thoſe which Mr. Macquer in his Chemical Lectures calls *primitive integrant molecules*.

In the ſame manner that we conceive that a body may be divided into its primitive integrant molecules, without any change of its nature, or other alteration than a diminution of its bulk; ſo we may alſo eaſily perceive, that if theſe pri-

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nitre gave a reddiſh brown color, to oriental agate a blacker ſtain, and changed the yellow ſpots of an agate to purple. The ſtone after the application of the metallic ſolution ought to be placed in the ſun; and the color may be rendered more intenſe by repeating the application of the ſolution. The liquor ſpreads ſo much on the ſtone, that neat deſigns cannot be made on it. Dr. Lewis propoſes to remedy this inconvenience by covering the ſtone over with etching wax, and the lines intended to be ſtained cut through this ground, in the manner of etching copper plates. The colors given to theſe ſtones may be deſtroyed by fire or by aqua fortis; and the colors thus deſtroyed by aqua fortis are recoverable by expoſure to the ſun. Agates and other ſtones may be ſtained black by applying to them a ſolution of copper in aqua fortis, and afterwards expoſing them to a red heat in a crucible. See *Lewis's Commerce of Arts*. Mocha ſtones may be imitated by moiſtening the ſmooth ſurface of an agate with a ſolution of copper, and on the middle of this ſurface ſetting an iron nail upright on its head. The iron abſorbs the acid from the copper, and the copper forms ramifications. If the nail be then removed, and the corroded iron carefully waſhed off by dipping the ſtone in water, the vegetations may be rendered by a red heat, of a black color. Theſe vegetations are not fixed in the ſtone, which ought therefore to be covered with a plate of cryſtal glaſs.

mitive integrant molecules, which are all homogeneous and of the ſame nature, and which are ſuppoſed ſeparated from each other, ſhould be brought to unite and combine together, no new body, that is, a body of different nature, will reſult from this union, but only a more conſiderable maſs of the ſame body: that is to ſay, for inſtance, that if the primitive integrant molecules were common ſalt, their reunion would ſtill form common ſalt, only in a maſs ſo much larger, as there is a greater number of theſe molecules united together. But it is the union of theſe homogeneous parts, of theſe primitive integrant molecules, which modern chemiſts have called *aggregation*; and they have called *aggregates* bodies conſidered as reſulting from their primitive integrant parts, in oppoſition to the names *mixts* and *compounds*, which they have given to bodies conſidered as reſulting from the union of their conſtituent parts, which are ſubſtances heterogeneous, and of different natures.

The name of integrant parts, which has been given to thoſe whoſe union forms aggregates, agrees well with them; becauſe, in fact, this union is a kind of addition or integration (if ſuch a word may be uſed) of a certain number of parts of the ſame kind, whence reſults a ſum, or a whole.

It is very eſſential to obſerve on the ſubject of aggregation, that we ſhould have a very falſe idea of it, and entirely oppoſite to chemical phenomena, if we underſtood by this word nothing but a ſimple juxtapoſition of the integrant parts of bodies: for beſides that, there muſt be a real adheſion and intimate union of theſe ſame parts with each other, ſo that they cannot be ſeparated but by ſome force ſuperior to that by which they are united. A heap of ſand, for example, if we conſider the grains of ſand as its integrant parts, cannot be regarded as an aggregrate, becauſe theſe grains are only *juxtapoſited*, and have no real adheſion together; ſo that the reſiſtance which they oppoſe to their ſeparation can only proceed from their gravity, and is not the effect of adheſion, or tendency to each other.

In the ſecond place, it is neceſſary to obſerve on the ſubject of aggregation, that the force of adheſion of the integrant parts of different bodies varies much, according to the nature of theſe bodies, ſome of them adhering very ſtrongly, and others very weakly; and that thoſe which adhere weakly are generally the eaſieſt to be diſſolved, conſidering that the ſolution of a body, or its combination with another body of a different nature, cannot be effected but ſo far as the integrant parts of theſe bodies are ſeparated, or their aggregation broken; which is partly done by the operations of art, but chiefly by the action of menſtruums.

All theſe conſiderations on the aggregation of bodies, although very ſimple in themſelves, are of the greateſt importance in the theory and practice of chemical operations. Becker and Stahl were the firſt who explained theſe ideas, which have been ſince illuſtrated and extended by the beſt modern chemiſts. *See the words*, AFFINITY, COMPOSITION, SOLUTION, DECOMPOSITION, DIVISION *of* BODIES.

XXIV. AIR. Air is a fluid inviſible, inodorous, inſipid, imperceptible to all our ſenſes but the touch, and is conſidered as a ſimple elementary body, and primary principle, becauſe it cannot be altered or decompoſed by any known methods.

The air is always in form of a fluid, though perhaps that fluidity is not eſſential to it. But it is certain that no cold has ever yet been produced, natural or artificial, ſtrong enough to deprive it of its fluidity.

We cannot flatter ourſelves that we can have air, any more than the other elements, in perfect purity. On the contrary, it is always found mixed with more or leſs of foreign ſubſtances, proceeding from a perpetual exhalation of volatile matters, and particularly of water, with which it has even a certain degree of adheſion. *(x)*

The primary integrant parts of air, although certainly very ſmall, yet are not ſo ſmall as thoſe of water, and even thoſe of other liquids leſs ſimple, ſuch as ſpirit of wine and oils: at leaſt, theſe liquids paſs eaſily enough through the pores of ſeveral ſubſtances, ſuch as paper, the ſkin, &c. through which the air does not paſs, or paſſes with difficulty.

The experiments of Mr. Boyle, and more particularly thoſe of Dr. Hales, related in his Vegetable Statics, prove that moſt vegetable and animal matters contain a prodigious quantity of air; and ſcarcely credible, if the effects it produced were not ſo conſiderable and ſenſible. Chemical experiments alſo give us many occaſions not only of obſerving theſe phenomena, but alſo of aſcertaining the quantity of air diſengaged, or abſorbed in ſeveral operations. *(y)*

It appears that air, as well as other primary principles, is found in bodies in two different ſtates: that is to ſay, that in certain bodies, and in certain circumſtances, it is merely diſperſed and interpoſed betwixt the integrant parts of thoſe bodies, but without adhering to theſe parts, or at leaſt adhering but very weakly. This air, which may be ſeparated by means purely mechanical; ſuch as the operations of the air-pump, compreſſion, or ſhaking; and which beſides poſſeſſes all its other properties; ought not to be conſidered as one of the elements of thoſe bodies in which it exiſts. But that portion of air which cannot be ſeparated from many bodies but by analyſing them, and by employing ſuch means of decompoſition as chemiſtry furniſhes; which, beſides while it remains in thoſe bodies, is deprived of one of its eſſential properties, its elaſticity, which it does not recover till it is diſengaged; this air, I ſay, ought truly to be conſidered as one of the elements or conſtituent parts of theſe bodies.

(x) Air not only *adheres* to water, as the text ſays, but chemically combines with it, and probably with many other volatile matters. The diſſolving power of air, as of other menſtruums, is encreaſed by heat; and hence upon an acceſs of cold, the air depoſits part of its water which it kept diſſolved while its heat was greater. The water depoſited becomes then viſible, forming fogs, or condenſing upon any cold body, as upon glaſs windows. This diſſolving power of air is alſo effected by other circumſtances beſides heat: for we find that in equal heats air ſometimes imbibes water faſter than at other times. Dr. Gould found that vitriolic acid ſaturated with water by long expoſure to air, did ſometimes loſe and ſometimes gain weight, according as the air was diſpoſed to depoſit or diſſolve moiſture. By what circumſtances this diſſolving power of the air is effected, and how theſe various ſtates of the atmoſphere affect the health of vegetables and animals, are ſubjects worthy of enquiry.

(y) Whether the permanently elaſtic vapors produced in diſtillations and other operations be really atmoſpherical air altered by its union with the bodies from which it is diſengaged, has not been hitherto ſhewn. It has been called fixed or fixable air. *See* AIR (FIXABLE).

The properties of pure air, and which occaſion many effects in chemiſtry, are:

1. Its *expanſive power*; that is to ſay, that it is capable of great rarefaction, and of occupying a ſpace thirteen times larger than its original ſize, when it is expoſed to the greateſt poſſible heat. This great expanſibility of air, added to the prodigious quantity of it which is diſengaged in many chemical analyſes and mixtures, occaſions frequently violent exploſions, againſt which an intelligent artiſt ought always to be on his guard. *(w)*

2. Its *compreſſibility*; that is to ſay, that the effect contrary to that we have been mentioning, is produced upon it by means of cold and of preſſure.

3. Its *elaſticity*; which is nothing elſe than the force with which it endeavours to reſume its natural condition, when it is violently rarefied, compreſſed, or condenſed; and the effort which it makes for that purpoſe upon bodies which oppoſe its re-eſtabliſhment.

4. Its *weight*; which determines it to fall impetuouſly into all the ſpaces into which it can have acceſs, and which are unoccupied by air, or more ponderous bodies. The experiments which demonſtrate all theſe properties of the air are ſo numerous and deciſive, that nothing is better known and illuſtrated in natural philoſophy. On this ſubject may be conſulted the works of Paſcal, Boyle, Mariotte, Abbé Nollet, and, in a word, of all the experimental philoſophers. It is only neceſſary to obſerve here, that the ſpecific gravity of air is to that of water, nearly as 1 to 850.

5. The faculty which the air has of conſiderably *facilitating the evaporation* of volatile matters ſublimed by the fire. It is a well-eſtabliſhed fact in chemiſtry, that the acceſs of air greatly accelerates all evaporations and diſtillations. We ſee, for example, that by directing the blaſt of bellows upon the ſurface of any volatile body evaporating by means of fire, as water, antimony, mercury, &c. that the ſmoke or vapors of theſe bodies are very ſenſibly encreaſed. It is alſo certain that any diſtillation of a liquor, as of water, is much haſtened, by directing upon its ſurface in the inner part of the alembic, the wind of a ventilator, as an Engliſh[*] author has propoſed. *See* DISTILLATION and EVAPORATION. *(z)*

(*w*) Air is expanded ⅓ of its bulk by the heat of boiling water. *See the Hiſtory of the Academy of Sciences* 1699. Hales found that the air in a retort, when the bottom of the veſſel was juſt beginning to be red-hot, was expanded to twice its former ſpace, and in a white or almoſt melting heat it occupied thrice its former ſpace or more; and Mr. Robins, a very accurate experimental philoſopher, found that air was expanded by the heat of iron juſt beginning to be white to four times its ſize. As greater expanſions cannot be well eſtimated, I preſume there is an error in that part of the text to which this note refers, where the air is ſaid to be capable of expanſion to thirteen times its ordinary bulk.

(z) Air accelerates evaporation by its diſſolving power, which is indeed the principal or only cauſe of evaporation, if by that word we mean the eſcape of any fluid with leſs heat than is neceſſary to convert it into vapor in a vacuum. By the ſame power air may alſo accelerate diſtillations, in which the heat is ſufficient to raiſe the fluid into vapor in a vacuum; but if the air be cold, it will probably more impede the diſtillation by cooling the ſurface of the fluid, and condenſing part of the vapor, than accelerate the eſcape of vapor by its diſſolving power.

6. Laſtly, the moſt ſingular property of air, and at the ſame time one of the moſt intereſting in chemiſtry, is, that no combuſtible ſubſtance can burn without its acceſs; and that the more ſtrongly it is impelled againſt burning bodies, the more rapid is the combuſtion. Hence it follows, that as the moſt part of chemical operations cannot be performed without the aſſiſtance of fire, a conſtant current of air more or leſs ſtrong, and in a certain direction, is neceſſary to produce the heat requiſite in theſe operations. Theſe currents of air are procured by bellows applied either to a forge, or to a melting furnace; or they are procured merely by the conſtruction of the furnaces; which is done in ſuch a manner, that by means of a ſpace left in the upper part of the furnace, in which the heat keeps up a perpetual vacuum, the external air is determined and forced to enter by the aſh-hole, to fill the vacuum above, and conſequently forms a current which conſtantly paſſes through the fire, and which is ſo much more ſtrong and rapid as the vacuum of the furnace above is greater. That is a fundamental principle from which general rules may be deduced, applicable to the conſtruction of all poſſible furnaces. *See* BELLOWS, FORGE, and FURNACE.

Boerhaave, in his Treatiſe on Fire, and M. Geriké, Doctor of Phyſic, and Member of the Royal Academy of Berlin, who has alſo given a very large Diſſertation on Fire, in a very good work, printed in 1741, entitled *Fundamenta Chymiæ Rationalis*, are of opinion, that the acceſs of air is neceſſary to the combuſtion of ſubſtances; becauſe, by its weight and ſpring, it keeps the flame conſtantly applied to the combuſtible body, and encreaſes their contact.

But this theory does not ſufficiently explain why combuſtible bodies may be kept red-hot in cloſe veſſels, without any conſumption; becauſe then it cannot be doubted but that the matter of fire is, by the movement excited during ignition, continually applied and even impelled upon the combuſtible body, without its burning or conſuming. It has then all the appearance of a body burning and penetrated by fire, but it is by an extraneous fire that it is ſo penetrated; its own inflammable matter is not conſumed, and reſts unalterable in midſt of a moſt intenſe fire.

However this be, it is very certain that the acceſs of air is indiſpenſibly neceſſary to maintain the combuſtion of bodies. But it is at the ſame time very difficult to find the true cauſe of this fact. The phenomena of combuſtion ſeem to prove, that the air materially concurs to the production of flame, and makes a part of it: for a given quantity of air can maintain only during a limited and determinate time, the combuſtion of a certain quantity of inflammable matter. If, for example, a lighted wax candle be placed under an inverted glaſs bell, which is joined exactly to its ſupport, the flame of the wax candle ſubſiſts during a certain time, ſo much longer as the bell is larger, but conſtantly diminiſhing till at length it is extinguiſhed; becauſe the quantity of air contained in the bell being a determinate quantity, and not capable of being renewed, cannot ſerve but for a certain quantity of combuſtion. Another phenomenon worthy of obſervation in this experiment is, that after the extinction of the wax candle, a real vacuum is formed under the bell, which is then as ſtrongly preſſed upon its ſupport, as if a vacuum had been made by an air-pump; which proves demonſtrably that the air which it included, materially concurred to the production of flame; ſince, if it were not ſo, the air being greatly rarified by the heat within the bell, would, on the contrary, make an effort to raiſe itſelf, and would eſcape violently as ſoon as it could. (a)

If we reflect but a little on theſe phenomena, many queſtions occur very intereſting, but at the ſame time very difficult of ſolution. In fact, does the air, which diſappears in this experiment, form a new compound with the inflammable principle of the burnt body by a new combination? If it be ſo, what is this compound? and what becomes of it? or is the air itſelf a neceſſary pabulum or food of flame? is it decompoſed by the act of combuſtion? If ſo, the air, is not a ſimple body: what then is the nature of its principles? and what becomes of them?

XXV. AIR (FIXABLE). (b)

XXVI. ALABASTER. The name Alabaſter is given to ſtones externally reſembling marble; of a hardneſs nearly equal; but inferior, and

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(a) A partial vacuum only is formed by this experiment. Dr. Mayow found that $\frac{1}{30}$th part of the elaſticity of the air in a cloſe veſſel was deſtroyed by the burning of a candle till it was extinguiſhed; and Dr. Hales found this diminution of elaſticity of air, by the ſame means, to be $\frac{1}{26}$th part. Dr. Hales alſo found that $\frac{1}{30}$th part of the elaſticity of air contained in a cloſe veſſel was deſtroyed by burning ſulphur. All the air contained in cloſe veſſels in theſe experiments was not, however, rendered fixable by the burning of the candle till it ceaſed to flame; for Mr. Cavendiſh found that $\frac{1}{9}$th part of fixable air was ſufficient to render a quantity of common air unfit for the maintenance of the flame of a candle. See Phil. Tranſ. 1766.

(b) AIR (FIXABLE). By this term we mean thoſe permanently elaſtic vapors which are diſengaged from almoſt all bodies when decompoſed by diſtillation, from vegetable and animal ſubſtances by fermentations, and from many matters during their combination with other ſubſtances.

This ſubject is one of the moſt intereſting in chemiſtry. Little more was known concerning it, than that permanently elaſtic fluids were producible from the ſubſtances, and by the methods mentioned in the above definition; till lately that the phenomena attending the combination of theſe fluids with, and their expulſion from, thoſe ſubſtances, together with ſome other properties, have been inveſtigated by experiments. The author of this *Dictionary* ſeems to have been unacquainted even with thoſe diſcoveries which were publiſhed before this work. Of theſe the moſt important have been deduced by Dr. Black, from experiments ſo conducted and related, that his treatiſe may be conſidered as an excellent ſpecimen of the beſt method of inveſtigating and demonſtrating chemical truths. *See Eſſays Phyſical and Literary, publiſhed at Edinburgh.*

The diſcoveries already made enable us to explain many chemical phenomena. We ſhall have frequent occaſions to ſupply the defects of the text in this particular, and to correct ſome errors that prevailed in the theory of chemiſtry till lately. The ſubject is ſtill new, and much may be expected from further experiments.

Some fixable air is *inflammable*, and ſome is *not inflammable*. We ſhall treat firſt of the latter kind, to which the name *fixed*, or *fixable air*, has been more peculiarly applied.

An uninflammable permanently elaſtic fluid may be produced by various methods, and from various ſubſtances. As the identity or diverſity of the kinds of the ſeveral fluids thus variouſly obtained has not been yet aſcertained, we ſhall mention what we know of each ſeparately, diſtinguiſhing them only by the methods of their production.

1. A permanently elaſtic fluid may be obtained *from alkaline ſubſtances by combining theſe with acids*, or *by calcination*. Alkaline ſubſtances ſeem to have a power of combination with this fluid, and with it form compounds, ſome of the properties of which are different from the properties of theſe ſubſtances when uncombined. This power of combination

ſuſceptible of a ſimilar, but leſs lively and ſparkling poliſh. Some alabaſters are white; and others are veined and colored, like marbles. When theſe ſtones are well poliſhed, their ſemitranſparency, which is more ſenſible than that of marble, gives them the appearance of agates.

is nevertheleſs weaker than that which alkaline ſubſtances have to acids, nor is it ſtrong enough to reſiſt the action of fire. Hence this fluid or fixable air may be diſengaged from thoſe ſubſtances by acids, or by fire when the alkaline ſubſtance is ſufficiently fixed to receive a violent heat. When alkaline ſubſtances have been by any means deprived of this fixable fluid, and are expoſed to an atmoſphere in which particles of it float, they readily abſorb it, unleſs they have been previouſly combined with ſome other ſubſtance, as an acid, with which they preferably unite, and again reſume their former ſtate. Hence all native alkaline ſubſtances are combined with this fluid. Thus, calcareous earth combined with this air forms the ſeveral maſſes of lime-ſtone, marble, chalk, and other ſtones and earths of this claſs. When any of theſe ſubſtances are deprived, by calcination or otherwiſe, of the fluid or air with which they are combined, they then become pure uncombined calcareous earth, or *quicklime*. Alſo fixed ſalts, obtained by incineration of veg are found to contain much fixable flu leſs they have been perfectly calcined; and volatile alkali, obtained by diſtillation of animal or of ſome vegetable ſubſtances, is ſaturated with this fluid. The principal differences which have been obſerved betwixt theſe ſubſtances combined, or not combined with fixable air, are, 1. By combination with fixable air they are rendered ſuſceptible of cryſtallization, which they are not wh n uncombined. Hence the uniform tex of marbles, calcareous ſpars, cryſtals of table or of mineral alkali, is extrication of this air. 2. By of alkaline ſubſtances with fixable air, power of combination with all other m which are incapable of expelling from this air, is diminiſhed. Hence, by this combination, the ſolubility of calcareous earth in water is deſtroyed: hence fixed alkali is leſs diſpoſed to deliquiate, or imbibe moiſture from the atmoſphere: hence vol alkali, which when combined is ſo ſtrongly diſpoſed to unite with water that it cannot be obtained in a ſolid or concrete ſtate, is rendered ſolid and cryſtallizable: hence the power of alkaline ſalts to diſſolve oil is greatly diminiſhed; ſo that ſoap-boilers find it neceſſary, in the preparation of ſoap, to deprive theſe ſalts, by quicklime, of all the fixable air with which they happen to be united: hence the cauſticity of calcareous earths is deſtroyed, and of alkaline ſalts is diminiſhed; and hence, theſe ſubſtances when combined with fixable air are diſtinguiſhed by the epithet *mild*, and when uncombined by the epithet *cauſtic*. 3. Alkaline ſubſtances combined with fixable air effervеſce with acids, which they do not, when rendered perfectly cauſtic; this effervеſcence being cauſed by the fixable air, which is diſengaged by acids from theſe ſubſtances.

This fixable air may be extricated from ſome alkaline ſubſtances by others, with which it has a ſtronger power of combination, and with which it does then actually combine. Thus mild volatile alkali may be deprived of its air, or rendered cauſtic by plying to it uncombined magneſia, fixed ali, or calcareous earth, while theſe ſtances unite with that air, and are there ndered mild. Magneſia may be depri f its air by cauſtic fixed alkali and cal ous earth; and laſtly, mild fixed alkali be rendered cauſtic by quicklime or cauſtic calcareous earth, which is thereby rendered mild. Thus by adding a mild fixed alkali to lime-water, which is a ſolution of cauſtic calcareous earth in water, the calcareous earth will take the fixable air from the alkali, will become mild, conſequently unſoluble in water, and hence will be precipitated.

Fixable air has a weaker power of combination than acids have with alkaline ſubſtances; hence theſe ſubſtances may be deprived of their fixable air by acids; and accordingly, when calcareous earth is precipitated from marine acid by a cauſtic alkali, it is found to be in a cauſtic ſtate, or quicklime.

The quantity of fixable air contained in marble was found by Mr. Cavendiſh (Phil. Tranſ. 1766) to be [illegible] of the whole; in

Naturaliſts diſagree in their opinions about the kinds of ſtones which ought to be called *alabaſters*. For ſome authors give this name to certain ſtones, which are abſolutely calcareous, while others give it to ſtones of a gypſeous nature. Of the latter claſs of naturaliſts is Mr. Pott, who admits no calcareous alabaſter, and

volatile ſal ammoniac, $\frac{525}{1000}$; and in cryſtals of ſalt of tartar $\frac{423}{1000}$.

The ſpecific gravity of this fixable air was found by Mr. Cavendiſh's experiments to be to that of water as 1 to 511, or to the ſpecific gravity of atmoſpherical air, when this is 800 times lighter than water, as 1 $\frac{57}{100}$ to 1.

This fixable air is noxious to animals, and extinguiſhes flame. Theſe properties probably do not proceed from its interception of common air, but from ſome peculiar quality; for Mr. Cotes found by experiments, that fixable air was more injurious to animals than a vacuum; and from Mr. Cavendiſh's experiments we find that $\frac{1}{9}$ of fixable air, mixed with atmoſpherical air, occaſioned the extinction of the flame of a candle.

2. A permanently elaſtic fluid or fixable air is produced *by diſſolving metallic ſubſtances in acids*. From iron, zinc, and tin, diſſolved in the vitriolic or marine acids, an inflammable air is produced, of which we ſhall treat afterwards. From all other metallic ſubſtances, and from theſe above mentioned diſſolved in other acids, uninflammable airs are produced. An air alſo adheres to metallic ſubſtances precipitated by mild alkalies or earths, which they receive from theſe precipitating matters, and which gives them greater than their original weight. To adhering air Dr. Black attributes the fulminating property of the precipitate called *fulminating gold*.

3. An elaſtic fluid or fixable air is produced *by combining concentrated acids with oils, and reſinous ſubſtances, with ſpirit of wine and with water*. Theſe ſubſtances are alſo capable of abſorbing the fixable air of alkaline matters. Thus oil of olives was found to abſorb an equal bulk of it; ſpirit of wine 2¼ times its bulk, with the heat of 46° of Fahrenheit's thermometer. Water alſo abſorbed this air more copiouſly in cold than in hot weather. With a boiling heat, and even by expoſure to common air during a few days, it parted with the air it had abſorbed.

4. A fixable air is obtainable *from animal, vegetable, and ſome mineral ſubſtances by diſtillation*. By this method Dr. Hales procured from a cubic inch of deer's horn thirty-three grains of air, from Indian wheat $\frac{1}{4}$ of its weight, from well-water $\frac{1}{8}$, from Pyrmont water $\frac{1}{3}$, from nitre $\frac{1}{4}$, from tartar $\frac{1}{3}$, and from ſalt of tartar $\frac{1}{6}$ of the reſpective weights of theſe ſubſtances.

5. A fixable air is extricated from water merely *by taking off the preſſure of the atmoſphere*. An air may alſo be extricated by the ſame method from lime-water, which muſt be different from the air of alkaline ſubſtances, elſe it would precipitate the calcareous earth from the water, as Dr. Black has remarked.

6. Fixable airs are produced by the *vinous, acetous, putrefactive, and probably by all other fermentations*. Dr. Hales found that 42 cubic inches, of ale, which had been fermenting thirty-four hours, did continue to emit air from the 2d of March to the 9th of June following, ſometimes more and ſometimes leſs according to the heat of the weather; and that upon a ſudden change of weather from hot to cold, it reſorbed air. The whole quantity of air emitted was 639 cubic inches. Theſe airs are alſo deleterious to animals, and extinguiſh flame.

7. *Atmoſpherical air is rendered unfit for reſpiration, or combuſtion, by having been inſpired by animals or vegetables*, and is therefore probably reduced to the ſame, or to a ſimilar ſtate with ſome of the above mentioned fixable airs.

8. *Atmoſpherical air is rendered unfit for reſpiration or further combuſtion, by having aſſiſted the combuſtion of ignited inflammable bodies.* A conſiderable part alſo of its elaſticity is deſtroyed by this combuſtion: for by burning a candle in a cloſe veſſel till it ceaſed to burn from want of freſh air, the air contained in the veſſel loſt, according to Dr. Hales, $\frac{1}{20}$th, and according to Dr. Mayow, $\frac{1}{30}$th part of its elaſticity. Theſe effects are not produced upon air merely by heat; for we find from Mr. Hawkſbee's experiments, that air was not altered by paſſing through a heated glaſs tube, but was rendered noxious to animals by paſſing through heated tubes

firmly maintains his opinion in his Lithogeognoſia againſt Linnæus, Konig, Bruckman, and ſeveral other authors, who claſs alabaſter along with marbles and calcareous ſtones.

It cannot be doubted that the ſtone which Mr. Pott called alabaſter, and which he chemically examined, is actually gypſeous. His experiments evidently

of braſs and iron; glaſs being an incombuſtible ſubſtance, and metals, at leaſt thoſe called *imperfect*, being capable of calcination, which is a combuſtion, or diſſipation of their inflammable principle. Whence does this alteration of atmoſpherical air proceed? Is it that part of the atmoſpherical air is converted into fixable air, by combining with the phlogiſton or ſome part of the burning ſubſtances?

o A permanently elaſtic fluid or fixable air is produced *by deflagration of nitrous acid with any inflammable ſubſtance*. In this operation the acid diſappears, and an elaſtic vapor is produced. May we not thence infer, that the acid is converted by combination with ſome other ſubſtance, probably with the inflammable matter, or by decompoſition of its own ſubſtance, into elaſtic vapor? The author of this Dictionary in the article DETONATION OF NITRE adopts the opinion of Stahl, that the exploſion of nitre with inflammable matter is produced by rarefaction of water contained in nitre or its acid. This rarefaction does contribute to the effect produced, but is not the ſole or principal cauſe: for the vapor of water is condenſible by cold into a liquor ſimilar to the water from which it was formed, whereas the vapor of which we now treat is permanently elaſtic. Stahl did indeed maintain that the water was by this operation changed into air; but we have not ſufficient reaſons to believe the poſſibility of ſuch a converſion in any inſtance; and in this inſtance we know that the water of the nitre is, after the exploſion, condenſed, and forms what is called a *clyſſus*. See CLYSSUS OF NITRE, and DETONATION OF NITRE.

This elaſtic fluid was found by Mr. Robins to occupy, when compreſſed by the atmoſphere and reduced to the ſame heat, a ſpace equal to 250 times the ſpace occupied by the gun-powder before exploſion. And as the elaſticity of air appeared from his experiments to be encreaſed four times by the heat of iron juſt beginning to be white; if this fluid be equally affected by heat as air is, its elaſticity in the inſtant of exploſion is about 1000 times greater than the preſſure of the atmoſphere; a force ſufficient to produce the effects of gun-powder.

Theſe are the known kinds of permanently elaſtic fluids extricated from ſubſtances, in which they exiſted ſo combined, that their elaſticity was either deſtroyed or counteracted by a ſuperior force. The properties of theſe fluids have not been ſufficiently inveſtigated, to enable us to determine whether all or ſeveral of them be of the ſame or different kinds. Do not, however, the elaſtic fluids produced by combuſtion, and extricated from alkaline ſubſtances, ſeem to be of the ſame kind, ſince a cauſtic alkali may be rendered mild by expoſure to the former fluid? Are not theſe two elaſtic fluids probably of the ſame kind with that obtained from ſome metals; or, at leaſt, have they not ſome principle common to them all, ſince metals deprived of their fixable air, or of the principle which renders atmoſpherical air fixable, by calcination, or by ſolution in acids, may be reduced to their proper metallic ſtate by applying combuſtible ſubſtances; and ſince ſeveral inſtances are given, by authors, of the reduction of metallic calxes by chalk, and other mild calcareous earths? Have not the fluids ſeparable from alkaline and metallic ſubſtances ſome analogy with acids? Like acids, they readily unite with, and effect the cryſtallization of thoſe ſubſtances. As a weaker acid is extricated from thoſe ſubſtances by a ſtronger, ſo is this air by all known acids. Are not the elaſtic fluids produced by the deflagration of nitre, and by the combuſtion or alkalization of tartar, and of other vegetable acid ſalts, formed from the acids of theſe ſubſtances combined with the inflammable principle? Whether theſe or many other conjectures, which might be made, be juſt or not, we may eaſily perceive that a judicious proſecution of this ſubject may tend to explain many important facts in chemiſtry.

Concerning

demonſtrate it. But, on the other ſide, it does not appear leſs certain, that the name *alabaſter* has been very anciently given to ſtones undoubtedly calcareous. The greateſt part of the antique vaſes and buſts, although univerſally called alabaſter, are of this kind. They are readily and entirely ſoluble in ſpirit of nitre with great effervescence, and are convertible by fire into quicklime.

The truth is, that ſculptors and artiſts, who work upon marble and alabaſter, ſeem to have given indiſcriminately the name *alabaſter* to ſtones which have only an external reſemblance to each other; that is to ſay, to ſtones which, to the other external qualities of marble, join alſo a more cryſtalline and more tranſparent appearance. Thus theſe artiſts have confounded under one name ſtones of very different kinds; and hence, among thoſe called alabaſters, ſome are truly calcareous, and others entirely gypſeous. Therefore if ſtones are to be named from their external appearances, we ought, in order to avoid a confuſion of two ſubſtances entirely different, to admit two kinds of alabaſters; one kind calcareous, of which the greateſt part of vaſes and buſts are made which are called alabaſter; and the other kind gypſeous, which is alſo uſed in ſculpture, and is that which Mr. Pott examined, and to which he aſſigns excluſively the name alabaſter.

Theſe difficulties being explained, chemiſts and naturaliſts are at liberty to take which ſide they pleaſe. They will always be underſtood when they diſtinguiſh in this manner the ſubſtances concerning which they write.

This being eſtabliſhed, the kind of ſtone which may be called calcareous alabaſter, has eſſentially all the properties of calcareous ſtones; for which reaſon, it is neceſſary to conſult, upon this ſubject, the articles EARTHS (CALCAREOUS) and QUICKLIME. We ſhall only obſerve here, that it appears demonſtrated, as M. d'Aubenton has advanced, that the differences obſervable betwixt calcareous alabaſter and marble, proceed only from the different manners in which theſe

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Concerning the *antiſeptic* qualities of fixable airs, *ſee* PUTREFACTION.

Inflammable permanently elaſtic fluids may be obtained by diſſolving zinc, iron, or tin in marine or dilute vitriolic acids. 356 ounce-meaſures of air were obtained from an ounce of zinc diſſolved in vitriolic acid, and alſo from the ſame quantity of zinc diſſolved in marine acid: 412 ounce-meaſures of air were obtained from an ounce of iron diſſolved in vitriolic acid; and 202 ounce-meaſures of air from an ounce of tin diſſolved in marine acid.

This inflammable air was not abſorbed by water, or by fixed or volatile alkalies.

Like other inflammable ſubſtances, it is only combuſtible by acceſs of atmoſpherical air, of which it requires an equal quantity for that purpoſe.

It was found by experiment to be eleven times lighter than atmoſpherical air, when the weight of this was to that of water as one to 800. Hence the quantity of air obtained from zinc, as above mentioned, was nearly $\frac{1}{24}$th part of the ſemi-metal.

An inflammable permanently elaſtic air is alſo producible from putrefying vegetable and animal ſubſtances. One grain of this air was obtained from 7640 grains of putrefying gravy broth, which contained about 163 grains of ſolid matter. The loſs of weight ſuſtained by this broth was much greater. The remaining part muſt have been according to Mr Cavendiſh (from whoſe paper on factitious air, Phil. Tranſ. 1766, all the above mentioned facts on inflammable air are copied) uninflammable fixable air, and ſome matter which communicated color and ſmell to ſoap-leys.

An inflammable permanently elaſtic fluid is frequently obſerved in mines, and is dangerous to miners. Theſe fluids are called *Damps*. See *the article* DAMPS.

two ſubſtances are formed; marble being of ancient formation, and the product of a depoſition of calcareous particles accumulated upon each other in banks and large maſſes: while calcareous alabaſter is formed alſo of calcareous particles, but in the way of filtration; and of *ſtalactites*, of which large enough maſſes are found to make vaſes, buſts, and even ſtatues. This difference in the formation of theſe two matters is ſufficient to explain the cauſe of the greater tranſparency of calcareous alabaſter. In fact, if a piece of calcareous ſtalactites be cut and poliſhed, no difference can be perceived betwixt it and works made of calcareous alabaſter.

As to the ſtone called *gypſeous alabaſter*, it has all the properties of gypſeous ſtones, and therefore it is neceſſary to conſult upon this ſubject the articles GYPSUM and PLASTER.

XXVII. ALCHEMY. This term has been employed by the pretended adepts, and by ſearchers after the philoſopher's ſtone, to diſtinguiſh that kind of chemiſtry the knowledge of which they flattered themſelves was reſerved for them alone. The adepts conſider chemiſtry as a vulgar ſcience, which ſcarcely contains the firſt elements of the myſterious ſcience of alchemy. But hitherto they have produced nothing which, in the judgment of ſenſible men, can give the leaſt grounds to ſuch a pretenſion. True chemiſts conſider alchemy as an imaginary ſcience, and thoſe who are devoted to it as perſons who, from want of better inſtruction, quit a reality for the ſake of a ſhadow.

XXVIII. ALEMBIC. An alembic or *ſtill* is a veſſel employed in diſtillations. There are ſeveral kinds differing from each other, either as to their form, or the matter of which they are compoſed.

The moſt frequent uſe of alembics is for diſtillations of very volatile principles drawn from ſeveral ſubſtances, particularly from vegetables. When the principles intended to be procured by diſtillation have no conſiderable action upon metals, and when they are ſuſceptible of riſing with a degree of heat which does not exceed, or but little, the heat of boiling water, copper alembics well tinned in their internal ſurface are employed.

The moſt convenient of theſe alembics, and which may be employed for many kinds of diſtillation, are compoſed of the following pieces. The firſt is a kind of pot deſigned to contain either the matters intended for diſtillation, or water, in which is immerſed another ſmaller veſſel of the ſame form, and made to contain the matters intended for diſtillation by the water-bath. Theſe pieces of the alembic are called in general *cucurbits*, becauſe formerly they were of an oblong form, upright, contracting themſelves in their upper part, and diminiſhing into a kind of neck, which made them reſemble a cucurbit, or gourd, or a *bladder*, by which latter name alſo they have been diſtinguiſhed.

The cucurbits of copper alembics uſed now have no reſemblance to this form: on the contrary, they are broad, not very deep, and wide. This new form of cucurbits is much more advantageous, as by it the diſtillations are much accelerated, with equal heat. The reaſon of this is, that the quickneſs of diſtillation is always proportionable to the quickneſs of evaporation; and that as evaporation is always made at the ſurface of bodies, the more ſurface theſe bodies preſent, the more quick and eaſy will be the evaporation. But the broad and wide form of modern cucurbits is infinitely more proper for the expoſing of much ſurface of the bodies contained, and particularly of liquid bodies, than the form of the ancient cucurbits, which were high and ſtrait.

The firſt of theſe two pieces is of copper, that it may reſiſt the action of the fire: the ſecond is generally of tin, and ought to be ſo ſhaped, that it can enter exactly into the former piece, and that they ſhould fit ſo well as to render any luting unneceſſary.

There ought to be a ſmall pipe or neck at the upper part of the firſt piece, which may be exactly cloſed, and through which water or other fluid may be introduced at pleaſure.

The third piece of the alembic is called the *capital*, becauſe it is a kind of head. This piece has the form of a hollow cone. It is furniſhed with a gutter or channel, which is placed along its inner and lower circumference.

This capital has alſo in its lower part a kind of neck, which ought to enter ſo exactly into either of the two former pieces, as no luting ſhall be neceſſary. Laſtly, it ought to have a pipe, called the *beak*, which opens inwardly into the gutter.

This beak ought to be from fifteen to eighteen inches externally, and ſo inclined, that it ſhall make with the neck of the alembic an angle of about ſixty degrees.

The fourth piece of a copper alembic is called the *refrigeratory*. It is a kind of bucket, ſurrounding the capital, to which it is exactly ſoldered in its lower part. In this, near its bottom, is inſerted a cock. The uſe of the refrigeratory is to contain cold water to facilitate the condenſation of vapors circulating in the capital. Its cock ſerves to empty the water when it is become too hot, that it may be ſupplied with cold.

As in copper alembics the refrigeratory and capital are joined, they may be conſidered as making only one piece. However, it is neceſſary to diſtinguiſh them; firſt, becauſe their uſes are very different; and, ſecondly, becauſe the refrigeratory is not eſſential to the alembic. Several chemiſts, good operators, are doubtful concerning its utility, particularly ſince the cuſtom was introduced of applying worms to alembics.

The *worm* is a long, tin, ſpiral pipe, included in a copper bucket, ſo that its upper and lower extremities ſhall come out of the bucket by two holes, round which they are well ſoldered. The upper extremity of the worm receives the beak of the alembic, and its lower extremity enters into a receiver fitted to it. The bucket containing the worm is filled with cold water, which cools and condenſes the vapors paſſing through it. The principal advantage which this refrigeratory has over that ſurrounding the capital, is, that it is not ſubject to retard or even to ſtop the diſtillation, as this latter one is: for this inconvenience has been obſerved to happen, whenever the capital of the alembic has been expoſed to a certain degree of cold. There is in M. Beaumé's Elements of Pharmacy a very exact deſcription, and a good engraving of a copper alembic with its worm.

The alembics deſcribed are of great uſe for the diſtillation of the *ſpiritus rector* of vegetables, of their *diſtilled waters*, of their *eſſential oils*, of pure *ardent ſpirits*, of ſpirits charged with the odoriferous principles of plants, and alſo for many other diſtillations of this kind. But as it is frequently neceſſary to diſtill in alembics acid and ſaline liquors capable of attacking metals, glaſs alembics are employed for ſuch diſtillations: and theſe are generally compoſed of only two pieces, namely, a cucurbit, and a capital, which is fitted above and joined by luting. There are glaſs cucurbits, high and ſtrait, which may be uſeful for the diſtillation of certain very volatile ſubſtances. Others are made ſhallow and broad, and theſe have the ſame advantages from their form as the metal ones have.

To avoid the luting of the capital with the cucurbit, theſe glaſs alembics have been made of one entire piece. The capital of theſe alembics, which are of cryſtal glaſs, ought to have an opening at its top, which may be exactly cloſed with a cryſtal ſtopper ground with emery. This opening is intended for the introduction of matters to be diſtilled, and for the extraction of the reſiduums after diſtillation. Theſe alembics of one piece, although ſometimes convenient, are ſeldom employed on account of their dearneſs, and of the difficulty of introducing, and of extracting ſolid matters.

There are alſo made cucurbits of ſtone-ware, and of glazed earthen ware, which are uſeful in many caſes. *See* at the word DISTILLATION ſeveral obſervations relative to the form and matter of alembic. *See Plate* I.

XXIX. ALKAHEST. This is a name given by ancient chemiſts to a pretended univerſal menſtruum. Such a menſtruum either does not exiſt, or elſe there is not any body in nature which may not become an alkaheſt. For although certain ſubſtances have not hitherto been combined with others, the daily diſcoveries in chemiſtry of combinations formerly believed impoſſible, ſeem to prove, that by certain management, and certain circumſtances, any ſubſtance may be combined with all others; or, in other words, that all bodies may be diſſolved by any ſingle ſubſtance. (c)

XXX. ALKALESCENT. This word is employed to denote a matter ſlightly alkaline, or which begins to turn to the alkaline and putrid fermentation.

XXXI. ALKALI (FIXED). Fixed alkali is a ſubſtance compoſed of acid, of earth, and of a little phlogiſton; and whoſe principles have to each other a weaker adheſion, than the principles of any acid have to each other. There are ſeveral kinds of ſaline alkaline ſubſtances. Theſe are vegetable alkali, mineral or foſſil alkali, and volatile alkali. They are all called by the general name *Alkali*, becauſe the following properties are common to them all.

1. Alkalies may eaſily be obtained dry and concrete, and freed from all water unneceſſary to their ſaline eſſence. (d) When they are in this ſtate,

2. They produce heat by adding water to them.

3. They attract the moiſture of the air, and deliquiate into a liquor. (e)

4. They change the color of ſyrup of violets into green, whether they be dry or fluid.

(c) Kunckel very well ſhews the abſurdity of ſearching for an univerſal ſolvent by aſking, "If it diſſolves all ſubſtances, in what veſſel can it be contained?"

(d) Volatile alkali retains water ſo ſtrongly that it cannot be obtained dry, unleſs by combining it with fixable air, and then it becomes cryſtallizable. The fixed alkalies may be rendered dry by application of heat, but are only chryſtallizable by help of fixable air. *See* AIR (FIXABLE).

(e) Mineral alkali does not deliquiate by expoſure to air; but on the contrary, when chryſtallized, it becomes dry, and loſes the water which is neceſſary to its chryſtalline ſtate.

5. They have an acrid, burning taſte, ſo much ſtronger as they are purer and dryer. This taſte has ſomething *urinous*: and hence they are called by ſome chemiſts *urinous ſalts*. They are alſo called *lixivial ſalts*, becauſe the method of obtaining fixed alkalies conſiſts in lixiviating the aſhes of certain vegetable ſubſtances.

6. They partly exhale with water, particularly when boiled in open air.

7. When they are dryed and re-diſſolved, ſome earth is always ſeparated from them.

8. They may be fuſed by a moderate heat.

9. When fuſed, they diſſolve all earths.

10. When added to earths and particularly to thoſe called vitrifiable earths, and expoſed to a ſufficient degree of heat, they and the earths become glaſs. *See* VITRIFICATION.

11. When added in a large proportion to the earths, with which they are fuſed or vitrified, they communicate to theſe earths all their own properties. *See* LIQUOR OF FLINTS.

12. They effervеſce and unite with acids to the point of ſaturation more perfectly and more intimately than pure abſorbent earths, and from this union reſult different neutral ſalts.

13. They decompoſe all ſalts with baſes of earths, metals, or volatile alkali. They ſeparate theſe baſes, and unite with the acids of the ſalts, with which they form new neutral ſalts. This is an example of ſtronger affinity, from whence reſult a new decompoſition and a new combination.

Alkaline ſalts being ſubſtances pretty ſimple, as well as acids, are powerful ſolvents. They are capable of combining not only with all acids and with all earths, as we have ſaid, but alſo with ſulphur and with oily matters. With ſulphur they form a ſulphureous ſoap, ſoluble in water, called *liver of ſulphur*; which *ſee*.

With oils, fat, reſins, &c. they form compounds, which have been called *ſoaps*. In each of theſe combinations, the alkali is a medium by which the inflammable ſubſtance, naturally unſoluble, and even immiſcible in water, becomes miſcible and ſoluble in that liquid. *See* SOAP.

Theſe ſaline ſubſtances can act alſo upon ſpirit of wine, when they are deprived of all the water unneceſſary to their eſſence as ſalts. Alkalies, in that ſtate, applied to ſpirit of wine, firſt deprive it of its ſuperfluous water; afterwards, when in a proper proportion, they act upon its own ſubſtance, by combining with it, and cauſing ſeveral alterations, and even a decompoſition of its parts. *See* SPIRIT *of* WINE (TARTARISED), and TINCTURE *of* SALT *of* TARTAR.

Laſtly, alkalies act upon metallic ſubſtances with more or leſs facility, according to their natures, and the different means employed; which ſhall be mentioned under the ſeveral articles of the alkalies and metals.

N. B. All that has been ſaid above concerning alkalies, may be applied to all the ſeveral kinds of alkalies, even to thoſe called *volatile*, excepting thoſe properties which depend upon fixity. Hence this article is applicable to alkalies in general. But it is neceſſary to obſerve, that a very juſt idea cannot be formed of theſe generalities, without entering into the details of what concerns the ſeveral kinds. *See* for the *affinities* of fixed alkali, and for its *medicinal virtues*, the word ALKALI (FIXED MINERAL).

XXXII. ALKALI (FIXED VEGETABLE). This name is given to all fixed alkalies obtained by burning any vegetable ſubſtances, and which have not the properties of the alkali, which is the baſis of common ſalt, which has been called the alkali of common ſalt, the *marine alkali*, *mineral or foſſil alkali*.

The common method of obtaining fixed alkalies from vegetable ſubſtances, conſiſts in burning theſe ſubſtances freely and in open air, till they be reduced to aſhes. *See* COMBUSTION *of* PLANTS. After which theſe aſhes are lixiviated with very pure water, till the water comes from them inſipid. This lixivium is evaporated to dryneſs; and what remains is the fixed alkaline ſalt of the plant, which may be deprived of its ſuperfluous water and ſuperfluous phlogiſton by calcination with a long and gentle fire.

Fixed alkalies obtained from any vegetable matters when well prepared and carefully purified by means hereafter to be deſcribed, are all exactly alike, and have the ſame properties; ſo that they are only one and the ſame kind of ſaline ſubſtance. But as it is very difficult to procure this ſalt in its utmoſt degree of purity, and as, in this reſpect, there is a difference betwixt thoſe obtained from different vegetable matters, ſome of them being naturally purer or more eaſily ſuſceptible of purification than others; and further, as ſufficient attention has not been given to the means of perfectly purifying theſe alkalies, two inconveniences have happened. The firſt is, that ſeveral chemiſts have imagined that there was an eſſential difference betwixt alkalies obtained from different plants: and the ſecond is, that other chemiſts have attributed to alkalies in general, ſeveral properties not belonging to them as alkalies, but to certain foreign ſubſtances adhering to them. We here conſider the vegetable alkali perfectly purified: and after we have enumerated its principal properties, we will treat of its origin, of its formation, and of the means of purifying it.

Fixed vegetable alkali has all the properties related under the article ALKALI (FIXED).

It is ſolid or concrete, like an earthy ſubſtance; of a fine white color; without tranſparency, or cryſtalline and regular ſhape, becauſe, in fact, it is not ſuſceptible of cryſtallization *(f)*; of no ſmell while it is dry, but of a ſlight lixivial ſmell when moiſtened with water. It has a violent, ſharp, burning, cauſtic and urinous taſte; that is to ſay, that when put in the mouth, it diſcovers a taſte of putrefied urine, which is cauſed by the diſengagement of volatile alkali from animal ſubſtances.

Here it is proper to obſerve, that when it is required to taſte fixed alkali, it is convenient to diſſolve and dilute it in much water, which only leſſens its ſtrength without altering its character: otherwiſe, the tongue might be bliſtered, becauſe calcined alkali is powerfully cauſtic, and quickly corrodes and deſtroys all animal matters. *(g)*

Fixed alkali, expoſed to air, attracts moiſture, with which it reſolves, or deliquiates into a white tranſparent colorleſs liquor like pure water. Fixed alkali

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(f) Fixed vegetable alkali does not ſo readily cryſtallize as mineral alkali does. It is nevertheleſs cryſtallizable by expoſing it to fixable air, with which it combines and forms cryſtals. *See* AIR (FIXABLE).

(g) The cauſe of this is, that by calcination fixed alkali is deprived of a part of its fixable air, and is thereby rendered more ſoluble, and conſequently more cauſtic. *See* AIR (FIXABLE).

attracts thrice its quantity of moiſture, according to Gellert. *Chemie Metallurgique, Tom. 1. p. 26.*

The ſame thing happens if it be purpoſely diſſolved in water. But in this latter caſe, at the firſt inſtant of the mixture, a pretty ſtrong heat is excited, by the activity of the union of alkali and water. This heat, however, is much leſs than what ariſes from the mixture of concentrated vitriolic acid and water.

Every time that fixed alkali is diſſolved in water, a portion of indiſſoluble matter remains. If the ſolution be filtered, it paſſes very clear: but after ſome time, it begins to be turbid, and ſmall flocks are formed in it of a matter which falls to the bottom of the veſſel, and cannot afterwards be rediſſolved. This matter is of the ſame nature as the firſt ſubſtance which we obſerved remains undiſſolved; and is nothing elſe than a portion of the earth of the alkali, which is ſeparated every time that the ſalt is calcined and diſſolved. The part which at firſt paſſes through the filter, and which afterwards renders the liquor turbid, is that part which was the moſt attenuated, and moſt adhering to the alkaline ſalt. This earth thus ſeparated, is no longer in a ſaline ſtate, and conſequently becomes indiſſoluble in water like pure earths.

Alkali diſſolved in the ſmalleſt poſſible quantity of water, forms a liquor leſs fluid, more thick, and unctuous than pure water, and which paſſes with more difficulty through the filter, from the quantity of ſaline matter with which the water is charged. When it is touched and rubbed betwixt the fingers, it appears to have a fat and oily nature; which proceeds from the greaſy particles of the ſkin diſſolved by it. Theſe properties have occaſioned it to be called, but improperly, an *oil*, by ancient chemiſts. *See* OIL *of* TARTAR. It ought to be called the *Liquor of alkaline ſalt*.

Dry fixed alkali, expoſed to a moderate fire, that is, a little more than cherry red, ſuſtains its action pretty well, altho' it fuſes, and diminiſhes in quantity. But by a very violent fire, the greateſt part of it is diſſipated in vapors, or even all of it, if the heat be ſufficiently long and intenſe. It is eaſy to be convinced of this by obſerving the pots in which glaſs is melted in glaſs-houſes. Above theſe pots a perpetual ſmoke may be ſeen, which can proceed only from the fixed alkali which enters into the compoſition of glaſs; the other matters which enter into that compoſition being infinitely more fixed than it.

Fixed alkali is a very powerful ſolvent. In the dry way, and by help of proper heat, it diſſolves all calcareous, vitrifiable, argillaceous, gypſeous, and metallic earths; and in certain proportions, and nearly in equal parts, it changes moſt of theſe into different kinds of hard, ſolid, and tranſparent glaſſes. *See* GLASS, VITRIFICATION, CRYSTAL-GLASS.

When a third or fourth part only of earth is added to it, they more readily fuſe, and unite together: and as the alkali is the prevailing principle in the new compound which reſults from this union, ſo its properties alſo prevail. Hence it renders the earths ſo diſſolved, ſoluble in water; and in acids, ſuſceptible of attracting the moiſture of the air, &c. *See* LIQUOR *of* FLINTS.

The alkali appears to have no action by the humid way upon ſubſtances purely earthy; but it has upon quicklime, to which it gives, and from which it receives, very ſingular alterations. When it is liquid, and treated with this ſubſtance,

ſtance, it becomes infinitely more cauſtic and more fuſible than it was before. *See* Lixivium *of* Soap-boilers, Cautery. *(b)*

Fixed vegetable alkali unites with the vitriolic acid violently and with great effervеſcence. The union of theſe two ſaline ſubſtances is very ſtrong and very intimate; and from thence reſults a perfect neutral ſalt, which is *vitriolated tartar*. *See* Tartar (Vitriolated).

With nitrous acid it forms *nitre*, a neutral cryſtallizable ſalt, the properties of which ſee under the word Nitre.

With marine acid, fixed vegetable alkali forms a particular kind of common ſalt, reſembling in many reſpects the natural common ſalt, but differing from it in others, and chiefly in its taſte, which is much leſs agreeable than that of common ſalt. The differences betwixt theſe two ſalts are cauſed by the difference of their alkaline baſes, natural common ſalt having for its baſis a particular kind of fixed alkaline ſalt, which differs conſiderably from the fixed vegetable alkali. The kind of common ſalt formed with this latter alkali and marine acid is called *regenerated common ſalt*, or Salt (Febrifugal) *of* Sylvius. *See* that article.

Fixed vegetable alkali unites alſo very well with vegetable acids, and with them forms different neutral ſalts, according to the nature of theſe acids. With the acid of vinegar, it makes a neutral deliqueſcent ſalt, of a very pungent taſte, called, *regenerated tartar*, or *Terra foliata tartari*; ſee theſe words. With the concrete vegetable acid, or cream of tartar, it forms a neutral cryſtallizable ſalt called *tartariſed tartar*, or *Salt (vegetable)*; which ſee.

Laſtly, fixed vegetable alkali unites alſo and forms true neutral ſalts with any ſubſtances, which, though not pure acids, do however act as acids with relation to alkalies. Such is the ſedative ſalt, with which this alkali forms a particular kind of *Borax*. *See* Borax and Salt (Sedative). Such alſo is arſenic, with which it unites to the point of ſaturation, and forms a very ſingular, neutral, cryſtallizable ſalt, the properties of which were firſt obſerved by M. Macquer, who gave it the name of *neutral arſenical ſalt*. *See* Salt (Neutral Arsenical).

Fixed vegetable alkali diſſolves ſulphur in all its ſubſtance; that is, it unites with both the acid and the phlogiſton of which this mineral matter is compoſed. It only diminiſhes the adheſion of theſe two conſtituent parts of ſulphur. This union of alkali with ſulphur may be made in the humid way and in the dry way; but much better in the latter. Hence reſults a particular ſaponaceous body, called *liver of ſulphur*, which is a powerful ſolvent of all metallic ſubſtances. *See* Liver *of* Sulphur.

Metallic ſubſtances are capable of being attacked and diſſolved by pure alkali. Some of them, ſuch as iron, and particularly copper, need only to be digeſted in the liquor of alkaline ſalt, to be perfectly diſſolved. Moſt of the others require to be previouſly diſſolved by acids: but by means of this ſolution in acids they become very ſoluble in alkali. For this purpoſe it is neceſſary to pour ſome drops of metallic ſolution into a very ſtrong liquor of alkaline ſalt: at firſt a precipitate is formed, which diſappears when the liquor is agitated; thus the

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(*b*) The cauſticity which alkaline ſalts acquire by being treated with quicklime, is occaſioned by this ſubſtance depriving them of fixable air, to which it has a ſtronger power of combination than they have. *See* Air (Fixable).

acid metallic ſolution is to be continued to be poured in at different times into the alkaline liquor, till this latter cannot any longer diſſolve the precipitate.

All metals are not by this method diſſolved with equal facility, and in equal quantities by fixed alkali. The lunar metals, namely, ſilver, mercury, and lead, are diſſolved by it with more difficulty and in leſs quantity than the ſolar metals, ſuch as gold, platina, tin, copper, and eſpecially iron. This laſt metal gives to the alkali while it is diſſolving a beautiful ſaffron color, approaching to red. This ſolution of iron by alkali was firſt publiſhed by Stahl, and by him called *martial alkaline tincture.* See TINCTURE (MARTIAL ALKALINE) *of* STAHL.

It is proper to obſerve upon the ſubject of the ſolubility of metals in fixed alkali; 1. That in order to its ſucceſs, it is very neceſſary that the previous ſolution of metal in an acid ſhould be very acid, and very far from the point of ſaturation. In whatever manner the operation is done, it always fails in making the martial alkaline tincture of Stahl, if a very ſaturated ſolution of iron in nitrous acid be employed. M. Macquer and Mr. Beaumé have aſcertained the neceſſity of this management, which is not obſerved by Stahl or any other chemiſt.

2. Moſt of theſe metallic ſolutions in alkali preſerve their limpidity only during a certain time: after which they become turbid, and a depoſition is then formed, of the ſame color as the ſolution. This depoſition is nothing elſe than a portion of the diſſolved metal which ſeparates from the ſolvent, as happens to ſeveral ſolutions of metals in acids.

3. A very illuſtrious chemiſt recommends for the ſolution of metals in fixed alkali, particularly of gold, ſilver, mercury, zinc, and biſmuth, an alkali phlogiſticated and fit to make Pruſſian blue. But this is the preciſe way to fail in the operation. This able chemiſt has been led into error by ſome of thoſe circumſtances, which are but too frequent in chemiſtry, and againſt which it is impoſſible for the moſt intelligent perſons to be always guarded. Some details upon this ſubject may be ſeen under the articles BLUE (PRUSSIAN), *and* TINCTURE (MARTIAL ALKALINE) *of* STAHL.

By fuſion and by the dry way, fixed alkali diſſolves and vitrifies all metallic calxes, or earths deprived of phlogiſton; perhaps even it is capable of diſſolving the metals uncalcined.

Fixed vegetable alkali unites eaſily with oils and oily ſubſtances, and communicates to them its property of mixing well with water. With them it forms ſaponaceous compounds, partaking of the properties of oil, and of thoſe of alkaline ſalt, as has been ſaid under the article of alkali in general. *See* the word SOAP.

As to the origin of fixed vegetable alkali, it is diſputed whether it exiſts ready formed in vegetables previouſly to their combuſtion, by which it is obtained, but which in this ſuppoſition does only diſengage ſubſtances which envelope and diſguiſe it; or whether vegetables contain only the materials proper for its formation, which conſequently takes place in the act of burning, and whether it be, properly ſpeaking, produced by fire.

There are reaſons for and againſt theſe two opinions, and they are ſo ſtrong on both ſides, that there are grounds to believe that both of them are true; that is to ſay, that the fixed alkali obtained after burning a vegetable, did partly exiſt ready formed in that vegetable before it was burnt, and that the other part was produced by the very act of combuſtion.

The proof of the former part of this propoſition is, that from moſt plants neutral ſalts whoſe baſes are fixed vegetable alkali, ſuch as vitriolated tartar and nitre, may be actually obtained without burning. And ſtill more: M. Beaumé, upon a particular examination of the plant called *corona ſolis*, found that this plant when well cultivated furniſhed not only a very conſiderable quantity of perfect nitre, very ſuſceptible of cryſtallization and detonation, the baſe of which conſequently was fixed vegetable alkali, but alſo a large quantity of this alkali, diſengaged from any acid, well diſtinguiſhed, and poſſeſſed of all its properties. An alkali then does exiſt in vegetables previous to burning. It remains to be examined whether this alkali exiſting in plants previous to burning, be truly one of their principles and conſtituent parts, or only a foreign and unneceſſary ſubſtance. What renders the latter opinion probable, is that the quantity of alkali in plants, whether diſengaged or united to an acid in neutral ſalts, is very variable, and that it appears to depend ſolely on culture and on the nature of the ſoil: ſo that it frequently happens, that the ſame plants which contain much alkali when theſe two circumſtances favor its introduction, contain none at all in contrary circumſtances.

As to the ſecond propoſition concerning the origin of fixed vegetable alkali, which is, that a great part of this alkali is produced and combined by the act of combuſtion, it is eſtabliſhed by ſeveral proofs ſeemingly inconteſtable. The obſervation of the circumſtances concurring to the production of alkali by burning, demonſtrates that this alkali is in great meaſure formed by the vegetable acid, which, during the deflagration of vegetables, combines in a particular manner with a portion of their earth and inflammable principle.

The following obſervations will render this truth evident.

1. When vegetables capable of furniſhing aſhes containing much alkali, are decompoſed by other means than combuſtion, ſcarcely any other ſaline matters are obtained from them but fluor acids, or what are properly called eſſential ſalts, which are nothing elſe than concrete acids rendered ſolid by a portion of oil and earth.

2. When vegetables are deprived of a part of their acid by diſtillation, or by extraction of their eſſential ſalts, the quantity of fixed alkali obtained from their aſhes is as much leſs, as the quantity of acid previouſly taken away was greater.

3. The matter of extracts containing almoſt all the acid of the vegetables uſed for that extraction, and the eſſential ſalts of vegetables are, of all vegetable matters, thoſe which furniſh the greateſt quantity of fixed alkali by burning in open air. The concrete acids particularly are changed by this proceſs almoſt entirely into fixed alkali. A ſtriking example of this is ſeen in the combuſtion of tartar, which is one of thoſe concrete acids.

4. Oils and oily concretions, which contain little acid and earth, leave after burning a ſcarcely ſenſible quantity of fixed alkali.

5. Plants which contain a very volatile acid, and thoſe from which no acid is obtained by diſtillation, ſuch as muſtard ſeed, leave alſo in their aſhes but an almoſt inſenſible quantity of fixed alkali.

6. All vegetables, even thoſe which in their natural ſtate furniſh aſhes containing much fixed alkali, when burnt, after their acid has been altered by a complete putrefaction, leave aſhes entirely free from alkali.

We cannot therefore but conclude, after having attended to theſe facts, that the greateſt part of the fixed vegetable alkali is produced from the acids of vegetables.

We ought alſo, after what has been ſaid on the origin and production of fixed alkali, to perceive the reaſon, why vegetable matters, which have undergone decoctions or long macerations in much water, as floated wood, leave but little or no alkali in their aſhes. The water has diſſolved and carried off either the alkali ready formed, or their acids and eſſential ſalts, which, as we have ſeen, are the principal materials of its compoſition.

Fixed alkali prepared by the incineration of vegetable ſubſtances, and by lixiviating and evaporating to dryneſs, is very far from the degree of purity requiſite in exact chemical experiments.

It is almoſt always altered; 1. By ſome remaining inflammable principle which could not be entirely conſumed during the burning; 2. By a portion of ſuperabundant earth; 3. By the mixture of different ſaline matters as fixed as itſelf, which partly or entirely elude the action of the fire. Theſe ſaline matters are either ſome neutral ſalts, which are frequently found in plants; ſuch as vitriolated tartar, Glauber's ſalt, common ſalt, and ſometimes a little nitre; or a portion of fixed mineral alkali. 4. As iron is diffuſed in almoſt all bodies, and particularly in greater or leſs quantity in the aſhes of vegetables, as Mr. Geoffroy has proved; and further, as iron is very ſoluble by fixed alkali; this ſaline ſubſtance is ſubject to be altered by mixture with iron.

Fixed alkali is diſcovered to be phlogiſticated, or altered by a ſuperabundance of inflammable matter; 1. By its color not being perfectly white, and by its lixivium or ſolution in water being more or leſs yellow, or red inſtead of being abſolutely colorleſs; 2. By the ſmell of its lixivium, which is always ſo much ſtronger, as it is more phlogiſticated; 3. By its degree of cauſticity, which is always ſo much leſs as it retains more ſuperabundant inflammable matter; 4. Laſtly, by its property of forming Pruſſian blue, by precipitating ſolutions of iron in acids, when it is much phlogiſticated. See upon this laſt article, BLUE (PRUSSIAN).

There are two methods of purifying fixed alkali thus altered, that is, of depriving it of all the ſuperabundant inflammable matter it contains. The firſt is by calcination, according to the general rules and with all the attentions neceſſary to be obſerved in calcining by fire. *See* CALCINATION.

The ſecond method of purifying fixed alkali from ſuperabundant inflammable matter conſiſts in applying to it a body on which it cannot act, and which has a ſtronger affinity than it with this inflammable matter. M. Beaumé firſt practiſed this ſecond method. This able obſerver, having perceived that when he evaporated in ſilver veſſels red and phlogiſticated alkaline lixiviums, theſe veſſels were more and more tarniſhed, till at length the ſurface of the ſilver became quite black, and that the lixivium loſt its color in proportion as the ſilver acquired it, carried this experiment as far as poſſible; and at length, by renewing the ſurface of the ſilver contiguous to the alkaline lixivium, he deprived this lixivium of all its color, and rendered it entirely white. This lixivium being then evaporated to dryneſs, furniſhed an alkali very white, very cauſtic, and free from all ſuperabundant phlogiſton. Beſides the practical method of dephlogiſticating alkaline ſalt, which this experiment ſuggeſts, it alſo confirms a truth demonſtrated by M. Macquer in his theory of Pruſſian blue; namely, that metallic ſubſtances may be charged with a ſuperabundant quantity of inflammable matter, and that they are capable of taking it from fixed alkali by the humid way. *See* Blue (Prussian).

The ſecond ſubſtance which alters fixed alkali is a ſuperabundant earth. As this earthy ſubſtance is not ſoluble in water when alone, and as it has but a weak adheſion to the alkali, it may be eaſily ſeparated by drying it once or twice by ſolutions and filtrations. But this purification muſt not be carried too far, becauſe the alkali itſelf is capable of decompoſition by this method, in detaching itſelf at every drying or calcination from a part of its earthy principle.

As to the ſaline matters which by their mixture alter the purity of the fixed alkali, they can be ſeparated by no chemical proceſs but by cryſtallization. This method is founded on the incapacity of the alkaline ſalt to cryſtalize, and on its property of decompoſing and of converting into cryſtallizable ſalts, all uncryſtallizable and deliqueſcent ſalts with which it may be mixed. It is then neceſſary to evaporate to the convenient point, the alkaline liquor from which theſe foreign ſalts are to be ſeparated, and to let it cool at ſeveral different times to favor the cryſtallization of thoſe ſalts which are beſt cryſtallized in the cold, or to continue the evaporation for thoſe ſalts which, like common ſalt, can only be cryſtallized by this method. *See* Crystallization. But it is manifeſt, that this method, however carefully performed, is incapable of procuring a perfect ſeparation of all the extraneous ſalts from the alkali; ſince while this continues fluid, it always remains mixed with a ſmall quantity of cryſtallizable ſalts, which are diſſolved by part of the ſame water which keeps the alkali fluid; and that the ſeparation by cryſtallization cannot take place but when all is evaporated to dryneſs. It is then impoſſible to ſeparate completely from the alkaline ſalt, the laſt ſmall portions of extraneous ſalts with which it was mixed. Notwithſtanding this, the degree of purity to which the alkaline ſalt may be brought by this method is conſiderable, and ſufficient for moſt of the operations of the arts, and even for many operations in chemiſtry.

It is ſtill more difficult to purify the alkali from iron. No practical method is known for this purpoſe. When therefore a very pure alkali is required, it is proper to chooſe ſuch ſubſtances as furniſh a ſalt the leaſt impure. For in this reſpect there is a great difference betwixt the ſubſtances from which it may be obtained, as will appear when we enumerate ſummarily the ſeveral alkalies moſt frequently uſed.

Fixed alkali being of great uſe, and much employed in arts, as it is the baſis of ſoap and leys, and much uſed in dying, making of glaſs and ſaltpetre, is procured from matters which furniſh a great deal of it, and at a ſmall expence.

The moſt common alkali, and at the ſame time the leaſt pure, is that of the aſhes of common hearths. Theſe aſhes are employed for lixiviums, in the manufacture of ſalt-petre, and in glaſs houſes where common bottle-glaſs is made.

In the Northern countries, where wood is plentiful, it is burnt on purpoſe, as well as many plants, to procure from their aſhes a ſtrong but very impure alkali, called *Pot-aſh.* This alkali is always much phlogiſticated, and contains many of the ſaline matters above-mentioned. Pot-aſh is employed for the purpoſes related. It is alſo uſed by dyers in ſome of their operations. Pot-aſh may be purified ſo far as to become a very good alkali by the methods mentioned. (*i*)

The dregs and leys of wine being dried and burnt, leave aſhes abounding in alkaline ſalt, called in French, *cendre gravelée*. This alkali is not only in great quantity in theſe aſhes, but likewiſe when the matters furniſhing it are properly and carefully burnt, it is the pureſt of all thoſe which are in commerce. If

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(*i*) The great conſumption of pot-aſh renders it a matter of importance. We ſhall therefore deſcribe the methods of preparing it.

In ſome parts of Germany it is prepared from the ſame wood of which charcoal is made. A number of tubes, made of plate iron, or of copper or braſs, are ſo diſpoſed in the pile of wood intended to be burnt into charcoal, that the water, acid, and oil, which are obtained in ordinary diſtillations, ſhall, when ſeparated from the wood by fire, paſs through theſe tubes into buckets placed to receive theſe liquors. The oil is then to be ſeparated from the acid liquor, which is then to be boiled in copper or iron veſſels, and the reſiduum dried and calcined. By this calcination, the acid ſalt is alkalized. This method, and the preparation of ſalt of tartar by calcining tartar, ſhew that vegetable alkali is produced by converſion of an acid to an alkali. How is this converſion effected?

The moſt common method of making pot-aſh, is by burning large piles of wood, lixiviating the aſhes by boiling in copper veſſels, decanting the lixivium when clear, and boiling in other copper veſſels till the liquor be evaporated and a reddiſh ſolid ſalt obtained, called *black pot-aſh*, which by calcination in ovens with a heat not intenſe enough to fuſe it, is dephlogiſticated and rendered white. If any of it has been fuſed, it will have a greeniſh blue color.

Another method of preparing pot-aſh, and which may be conveniently uſed in a large manufactory of it, is deſcribed by Kunckel. The aſhes of wood are put into a large tub, near the bottom of which is inſerted a cock; and to prevent the aſhes from filling up the cock, the bottom is covered with ſtraw and pieces of ſmall wood. Water is to be poured on the aſhes, and is the next day to be let off through the cock into another veſſel. The aſhes may be again elixated with more water till all the ſalt be diſſolved. The weaker leys are to be poured on freſh parcels of aſhes till they can receive no more ſalt. The ley is then to be evaporated in an iron pan, and the brown ſalt is to be dephlogiſticated by calcination in a furnace or oven with a heat not intenſe enough to fuſe it.—Some perſons ſoak ſtraw in the ley obtained by lixiviating wood-aſhes with water, and by drying and burning this ſtraw they obtain a ſalt without the trouble of boiling the ley. The alkaline ſalt called *pearl-aſh* has a whitiſh pearl color, and is almoſt entirely ſoluble in water. The Ruſſia pot-aſh is dark-colored, hard, not eaſily deliqueſcible, and contains (as Dr. Lewis ſays) more than half its weight of an earth unſoluble in water. Scheffer, in the Swediſh Memoirs for the Year 1759, ſays, that from 100lb. of Ruſſian pot-aſh he obtained 92½ lb. of alkaline ſalt, and 7½ lb. of neutral ſalts. Dr. Home found that Ruſſia pot-aſh contained a conſiderable quantity of quicklime. From experiments made by Brandt (*Memoires Suedoiſes* 1749), and from the preference given to it by ſoap-boilers, it appears to be more cauſtic, and more powerfully to diſſolve oils, than purer pot-aſh rendered cauſtic by quicklime. Ruſſian pot-aſh is ſaid to be prepared by burning wood with a cloſe ſmothering heat; making a ley from the coarſer part of the aſhes, and moiſtening therewith the finer part into the conſiſtence of a paſte, ſtratifying this paſte with ſome of the more inflammable kinds of wood, and ſetting the pile on fire. The neutral ſalts found in pot-aſh are chiefly vitriolated tartar, ſea-ſalt, with which latter ſalt pot-aſh is frequently adulterated to increaſe its weight.

it contains iron, it is in an inſenſible quantity, and it is naturally free from mixture of extraneous ſalts: therefore dyers and other manufacturers whoſe operations require a pure alkali, prefer theſe to any other alkaline aſhes.

Fixed Alkali *of* Tartar.

TARTAR, which is nothing but the concrete acid or eſſential ſalt of wine, being properly burnt, is almoſt entirely changed into an alkaline ſalt, very ſtrong, and the pureſt of all; and which therefore has been reaſonably preferred by chemiſts to any other. It is called the *Alkaline Salt of Tartar*, or ſimply *Salt of Tartar*. Hence this name has become in ſome meaſure ſynonimous with that of alkali.

Salt of tartar is made by wrapping up in wet brown paper the tartar intended to be burnt, and placing theſe parcels ſo wrapped up in a furnace, by beds or ſtrata, together with ſtrata of charcoal, alternately; and by ſetting fire to the whole, and continuing the fire till no more blackening ſmoak riſes.

As tartar is almoſt entirely changed into alkaline ſalt, it preſerves after incineration a certain conſiſtence, and retains the form it had before burning; which makes it eaſy to collect it properly. But too great heat muſt be prevented in burning tartar, otherwiſe the alkali would melt and flow to the bottom of the furnace, where it would mix with the impurities of the charcoal. To avoid this inconvenience a furnace entirely open may be employed, in which the charcoal may burn freely, but without any ſtrong current of air to render the heat too intenſe. On the other ſide, as fire is generally more intenſe in great than in ſmall operations, where proportionable quantities of combuſtible matters are uſed, when much tartar is to be burnt, it is proper to diminiſh the quantity of charcoal, to prevent too great heat, and the conſequent fuſion of the alkali.

When tartar is ſufficiently burnt, a lixivium muſt be made from it till the water poured on it receives no more taſte. It muſt then be filtered, evaporated, dried and calcined, according to the directions given to obtain the alkali of tartar in its greateſt purity.

Fixed Alkali *of* Nitre.

THE baſis of nitre being a fixed alkaline ſalt of the nature of the vegetable alkali, and the acid of this ſalt being capable of decompoſition and total deſtruction by deflagration, we may obtain ſeparately its alkali, called *alkaliſed or fixed nitre*, by burning or detonating it with combuſtible matters. As this combuſtion is very rapid, and as it is alkaliſed almoſt inſtantaneouſly by detonation, it has been alſo called extemporaneous alkali.

Thoſe vegetable ſubſtances only which contain an acid yield an alkaline ſalt by incineration. From muſtard and other vegetables which yield a volatile alkali and no acid by diſtillation, no fixed alkali can be obtained.

The aſhes of firs, pines, and all trees which contain much reſin and eſſential oil, yield a ſmall quantity only of fixed alkali by elixation. The cauſe of this ſeems to be, that the acid of theſe trees is very volatile, and together with a volatile inflammable matter forms the eſſential oils and reſins. *See* Resins.

The matters moſt convenient and moſt frequently uſed for the deflagration of nitre are charcoal and tartar. The alkali made by deflagration of nitre with charcoal is called NITRE *fixed by* CHARCOAL. *See* this article for the method requiſite.

Nitre and tartar burnt together produce a very ſtrong alkali, which is a mixture of the alkali of nitre and of the alkali of tartar, both which are entirely of the ſame nature. They are confounded together by the name NITRE *fixed by* TARTAR. *See* that article, and FLUX (WHITE).

Theſe alkalies of nitre, when well prepared, are very pure, and fit for the niceſt operations in chemiſtry.

All theſe ſeveral kinds of alkali, when perfectly purified, have entirely the ſame properties, and ought to be regarded only as one and the ſame alkali, which ought to be called *Fixed Vegetable Alkali*. The purification above-mentioned of this alkali is attended with conſiderable difficulties in practice. The chief of theſe difficulties is in the evaporation and drying of the alkaline lixiviums; and this relates to the veſſels employed in theſe operations. Veſſels made with the imperfect metals are unfit, becauſe they are liable to the action of the alkaline ſalt. Silver veſſels are the fitteſt of all for this purpoſe: but it is not very certain that this metal is incapable of being acted upon by alkali.

Glazed earthen veſſels, ſuch as common pottery-ware, cannot be employed, becauſe they are not, and cannot be ſufficiently baked. The alkaline lixivium paſſes through them as eaſily as through a filter. If veſſels not metallic are to be uſed, they ought to be of glaſs or porcelaine, or made of pure clay, and baked in a violent fire, ſuch as that kind of pottery called ſtone-ware. Theſe veſſels perfectly reſiſt the action of alkalies, but they are very liable to be cracked by heat.

Well-prepared fixed alkali ought to be preſerved, either dry or fluid, in cryſtal-glaſs bottles, with glaſs ſtoppers. When the fluid alkali is uſed, it muſt be gently decanted from the ſediment depoſited at the bottom of the bottles.

XXXIII. ALKALI (MINERAL *or* FOSSIL), or ALKALI (MARINE). This is a ſaline, alkaline, fixed ſubſtance, ſerving as a baſis to the acid of common ſalt, and forming with it the native neutral ſalt which is diſſolved in large quantities in the ſea, and known by the names *Common Salt* and *Sea-Salt*. As this ſalt is a natural production, and belongs neither to the vegetable nor animal kingdoms, it has been ranged amongſt minerals, and therefore called mineral alkali: notwithſtanding that a conſiderable quantity of this ſalt may be obtained from the aſhes of ſeveral vegetables. But its origin is always the ſame, and it is not to be conſidered a vegetable ſubſtance; for we ſhall ſee that mineral alkali obtained from vegetables, proceeds always from common ſalt contained in theſe vegetables. After we have mentioned the properties of this alkali, we ſhall deſcribe the method of procuring it in its greateſt purity.

Fixed mineral alkali has eſſentially and fundamentally all the properties of fixed vegetable alkali. It has the ſame taſte and the ſame fixity. It diſſolves all the ſame ſubſtances, and exhibits with them very ſimilar phenomena. It melts and vitrifies all earths, and is altered by quicklime in the ſame manner. It combines with all acids to the point of ſaturation, and with them forms neutral ſalts. It has the ſame action as fixed vegetable alkali on metallic ſubſtances, and forms ſoaps with oils and oily matters; therefore, in order to have a juſt idea of the alkaline properties of this ſaline ſubſtance, it is very neceſſary to read exactly and entirely what has been ſaid under the articles ALKALI and ALKALI (FIXED VEGETABLE). But it alſo differs very conſiderably from fixed vegetable alkali by ſeveral properties peculiar to it; and it is upon theſe properties we are chiefly to inſiſt in this article.

Fixed mineral alkali, which we here ſuppoſe to be in its greateſt purity, differs from fixed vegetable alkali.

1. By its taſte, which is a little leſs fiery and corroſive: but this difference is very ſlight.

2. When dried, it does not attract the moiſture of the air ſufficiently to form a liquid, as fixed vegetable alkali does.

3. If it be diſſolved in water, when it is dry and calcined, it does not heat the water nearly ſo much.

4. When diſſolved in water, and its ſolution evaporated and cooled, it coagulates into cryſtals, preciſely as neutral ſalts do. In this it differs conſiderably from fixed vegetable alkali, which is abſolutely deliqueſcent, and not cryſtallizable. (k)

The cryſtals of mineral alkali contain much water, and have but little adheſion to this water; for moſt of it is diſſipated by expoſure to open air. By this diſſipation of water the cryſtals loſe their form and tranſparency, which were owing, as of all neutral ſalts, to the water contained. *See* CRYSTALLIZATION.

Cryſtals of mineral alkali thus deprived of their water, fall into a white powder: therefore, to preſerve them, they muſt be put into bottles as ſoon as they are drained.

The differences related betwixt the vegetable and mineral alkalis ſhow that this latter poſſeſſes ſaline properties in a leſs eminent degree; which probably proceeds from the abundancy of its earthy principle.

5. Fixed mineral alkali diſſolves by fuſion, and vitrifies all earths like the vegetable alkali. But it has been obſerved, that it vitrifies earths better, and renders the glaſs more ſolid and durable. Probably this proceeds from the greater fixity of the mineral alkali, from its containing an earth leſs combined, and alſo from its want of the deliqueſcent quality.

6. With vitriolic acid, mineral alkali forms a neutral cryſtallizable ſalt called *Glauber's ſalt*, which differs from vitriolated tartar in the following circumſtances. 1. Its cryſtals are of a different figure and larger ſize. 2. They contain more water. 3. They are more ſoluble in water. 4. Their adheſion to the water of their cryſtallization is leſs, inſomuch that this ſalt by expoſure to air loſes its water, and conſequently its form and tranſparency, and becomes a white powder, as the mineral alkali does alſo when expoſed to air. *See* SALT *of* GLAUBER. As the ſame acid is in Glauber's ſalt and in vitriolated tartar, the differences above related muſt proceed from their alkaline baſes: therefore all the properties which diſtinguiſh Glauber's ſalt from vitriolated tartar are to be conſidered as the dif-

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(k) We have obſerved in a note upon the former article, that fixed vegetable alkali is cryſtallizable by expoſure to fixable air.

ferences betwixt the vegetable and mineral alkalis. The ſame obſervation may be applied to all combinations of mineral alkali with the other acids, of which we are now going to ſpeak.

7. With nitrous acid, mineral alkali forms a particular kind of nitre, ſuſceptible of detonation and of cryſtallization; but it differs from ordinary nitre, or that which has for its baſe fixed vegetable alkali, in the figure of its cryſtals, which, inſtead of being like long needles, are ſolids, each of which has ſix rhomboidal faces; that is to ſay, two angles of each face are acute, and the other two obtuſe. This figure, which is ſomewhat ſimilar to that of a cube, has occaſioned this ſalt to be called *cubic* or *quadrangular nitre*. This figure is cauſed by the mineral alkali. *See* NITRE (QUADRANGULAR).

8. With marine acid, mineral alkali forms common ſalt, the cryſtals of which are perfect cubes. This ſalt differs from the neutral ſalt formed by the combination of the ſame acid with vegetable alkali chiefly by its taſte, which is infinitely more agreeable. *See* SALT (COMMON).

9. Mineral alkali forms with the acid of vinegar a neutral ſalt entirely different from the *terra foliata tartari*, which is deliqueſcent and not cryſtallizable, while the former cryſtallizes well, and does not attract the moiſture of the air. This ſalt has no particular name. *See* SALT (NEUTRAL) *Compoſed of the* ACID *of* VINEGAR *and of* MINERAL ALKALI.

10. With the concrete tartareous acid, mineral alkali forms a neutral cryſtallizable ſalt, differing from that made with the ſame acid and vegetable alkali, or *vegetable ſalt*, by the figure of its cryſtals, which are alſo much larger and finer. *See* SALT VEGETABLE).

11. Mineral alkali very well diſſolves oils and oily matters, and with them forms ſaponaceous compounds, as the vegetable alkali does. But ſoaps made with this latter alkali remain ſoft, and do not acquire ſuch conſiſtency and hardneſs as thoſe made with mineral alkali. This difference is certainly cauſed by the property which mineral alkali has of cryſtallizing. *See* SOAP. *(l)*

It is probable, that if we were to examine attentively the combinations of marine alkali with ſulphur and metallic ſubſtances, ſenſible differences might be diſcovered from ſimilar combinations made with vegetable alkali. The diſcovery of theſe differences could not fail to throw new light upon the nature of this alkali. But I do not believe that ſufficient experiments have been made on this ſubject. *(m)*

Several celebrated chemiſts have, however, made conſiderable reſearches into the nature of marine alkali. The perſon who has done moſt in this way is M. Duhamel de Monceau, a member of the Academy of Sciences. He has publiſhed

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(l) The difference mentioned in the text does certainly not proceed from the cryſtallizing quality of mineral alkali; for this ſalt

air, renders it cauſtic, and incapable of forming cryſtals. *See* AIR (FIXABLE). The greater hardneſs of ſoaps made with mineral alkali than of thoſe made with vegetable alkali, probably proceeds from that property of mineral alkali by which it has a weaker power of combination with water than vegetable alkali has

vegetable alkalies; namely, that platina may be precipitated from its ſolution in aqua regia by the latter, but not by the former.

in ſeveral memoirs, a detail of many experiments made to decompoſe common ſalt, that he might obtain the alkaline baſis ſingle and pure, for the purpoſe of examining its properties. Common ſalt not being capable of decompoſition merely by the action of fire, and without the application of another ſubſtance, it was neceſſary to find ſome ſubſtance which could carry off the marine acid, without combining itſelf with the alkaline baſis. As phlogiſton produces this effect very well on thoſe neutral ſalts which are compoſed of a fixed alkali and vitriolic or nitrous acids, it was natural to try the ſeparation of the marine acid by the ſame intermediate ſubſtance. This M. Duhamel did, but without ſucceſs; altho' in his experiment he employed every reſource of the moſt enlightened chemiſtry. The ſame thing happened to Mr. Margraaf, who tried without ſucceſs to combine marine acid with phlogiſton, in order to produce phoſphorus. It appears, then, that art does not yet furniſh any method of decompoſing common ſalt by phlogiſton.

It is nevertheleſs probable that this decompoſition is not impoſſible, and that it even takes place every day in the combuſtion of maritime plants of the *kali* kind, all of which contain ſea-ſalt, and when burnt, furniſh a conſiderable quantity of cryſtallizable alkali, which being combined with the vitriolic and nitrous acids forms Glauber's ſalt and cubic nitre, entirely ſimilar to thoſe formed from the decompoſition of common ſalt by theſe two acids. It is very probable that this cryſtallizable alkali obtained from the aſhes of maritime plants, proceeds from a portion of ſea-ſalt contained naturally in theſe plants, a part of which is decompoſed by the burning; for it is certain that no trace of a diſengaged alkali can be obſerved in theſe plants previouſly to their incineration.

However that be, it is certain that this cryſtallizable alkali obtained from the aſhes of maritime plants, is entirely of the ſame nature as the natural alkaline baſis of ſea-ſalt. This is a truth which no chemiſt queſtions. But diſputes have ariſen concerning the ſaline alkaline nature of this ſubſtance.

The inquiries of M. Duhamel had proved to him, that it had the principal marks of a ſaline alkali; he concluded that it really was ſuch. On the contrary, the celebrated Mr. Pott, who has alſo made many experiments on this matter, has always maintained that it was only a pure earth, without the properties of an alkaline ſalt. This diverſity of ſentiments has occaſioned a literary diſcuſſion betwixt theſe two learned gentlemen, of that kind which always turns out to the advantage of ſcience; as it has occaſioned a great number of beautiful experiments, which greatly illuſtrate this matter

The ſtrongeſt proof brought by Mr. Pott in ſupport of his opinion may be found in the eclairciſſements given to the ſequel of the French tranſlation of his Lithogeognoſia. Mr. Pott ſays, “ that by a fixed or volatile alkali an inſipid and
“ perfectly inſoluble earth may be precipitated from the mother water of ſea-ſalt.
“ This earth united to the vitriolic acid forms a Glauber's ſalt perfectly ſimilar to
“ that prepared from ſea-ſalt. This Glauber's ſalt produces with charcoal a ſa-
“ line alkaline body, which is not precipitable by fixed vegetable alkali; which
“ alſo happens preciſely to Glauber's ſalt prepared with ſea-ſalt. This alkaline
“ ſalt is not produced by the vitriolic acid, nor by the charcoal, but principally
“ from this ſaline earth, which for that reaſon may be called an *alkaline earth*,
“ nearly approaching a ſaline ſtate, and which is capable of taking from acids a

“ proper portion of their moſt ſubtle parts, by combination with which it becomes a genuine alkali.”

As to what remains, it appears that, after the properties of fixed alkaline ſalts and of the baſis of ſea-ſalt have been eſtabliſhed, it is eaſy to decide the queſtion. Nothing can be ſaid more ſenſibly on this ſubject than the following quotation from the learned and judicious tranſlator of Mr. Pott's Lithogeognoſia. “ This “ queſtion is now reduced to a diſpute about words, ſince Mr. Duhamel agrees “ with Mr. Pott that the baſis of ſea-ſalt differs from the fixed alkali of nitre and “ others ſimilar; and that Mr. Pott agrees with Mr. Duhamel, that it differs “ from common abſorbent earths. But hitherto it ſeems that Mr. Duhamel's “ expreſſion is more juſt and conformable to the definition of ſaline ſubſtances.”

From all this we ought to conclude, that the baſis of ſea-ſalt is neither a pure earth, nor an alkali ſimilar to that obtained from vegetables, but a ſaline alkaline ſubſtance of a peculiar nature; and if conjectures may be allowed on the nature of this alkali, I ſhould be inclined to believe, that it differs from the vegetable alkali, either becauſe a larger quantity of earth enters into its compoſition, or becauſe its earthy principle is united to it more intimately.

Further, it appears that the baſis of common ſalt is truly of a ſaline nature, from its ſucceſsful and even advantageous application to all the ſame purpoſes in the arts as fixed vegetable alkali, as has been ſaid above.

The only practical method of procuring this alkali in great quantities is by the incineration of maritime plants. Theſe aſhes contain much mineral alkali, when the plants happen to grow in a favorable ſoil and climate, and the mineral alkali is found to be more or leſs pure, according to the nature of the plants and of the ſoil. Theſe aſhes are generally known in commerce by the name *Soda*. This ſoda is employed in arts without purification; hence there is obſerved a great difference betwixt different ſodas, ſome of which are much better than others. *(n)*

As the chemical affinities and the medicinal virtues of the mineral and of the vegetable alkalis are the ſame, we proceed to mention what is moſt material on theſe ſubjects.

The *affinities of fixed alkali*, according to Mr. Geoffroy's table, are in the following order: vitriolic acid, nitrous acid, marine acid, vinegar, ſulphur.

Mr. Gellert's table is more extenſive, and is as follows: Phlogiſton, vitriolic acid, nitrous acid, marine acid, vegetable acid, zinc, iron, copper, lead, tin, regulus of antimony, regulus of cobalt, arſenic and biſmuth. Gold and ſilver are marked in this table as indiſſoluble by fixed alkali.

As fixed alkalis are the greateſt abſorbents of acids, they are proper for all thoſe maladies deſcribed by Boerhaave as proceeding from a ſpontaneous acid.

(n) Mineral alkali is found lying upon the ground in the iſland of Tenerif, and in many other countries. The Spaniſh aſhes called *bariglia*, or *ſoda*, are produced by burning kali, varech, or fucus marinus, alga marina, and other maritime plants, previouſly dried, in pits dug in the ground. The fire employed is ſo violent as to fuſe the aſhes into one large and hard bluiſh maſs. From theſe plants Henckel obtained, by boiling in water, evaporating and cryſtallizing, a conſiderable quantity of marine ſalt. Stahl, Gellert, and other authors, prefer this ſalt to vegetable alkali, for the formation of glaſs, durable, and not attackable by acids. But Kunckel obſerves, that the impurities mixed with common ſoda, or bariglia, give a bluiſh color to glaſs, and render it liable to crack, when cooled. Stahl obſerves, that the ſame effect is produced by common pot-aſh. The mineral alkali, as has been obſerved in the text, makes a finer, harder ſoap than vegetable alkali. It is alſo ſaid to be more effectual in the reduction of metallic calxes.

They are even preferable to abſorbent earths, (although theſe latter are more frequently uſed) in caſes where, notwithſtanding ſigns of acidity, a putreſcent diſpoſition is apprehended; which is not at all impoſſible, becauſe they are, like all ſaline matters, antiſeptic, according to the obſervations of Dr. Pringle. But if the putridity was advanced to alkaleſcency, which is very rare, they would be very hurtful, becauſe they would encreaſe this alkaline acrimony.

It muſt not be ſuppoſed that fixed alkalis taken internally enter the blood-veſſels with their alkaline qualities. If that happened, they would be true poiſons, as acids are; ſince they quickly kill animals into whoſe veins they are injected.

The human conſtitution, which cannot ſuffer the preſence of any ſenſible and diſengaged acids or alkalis, at leaſt to a certain degree, in our fluids, acts upon alkalis taken internally by combining them in digeſtion with the acids of aliments, or with their oily parts, forming ſoaps, in which conditions only they can arrive at the blood.

Pure alkalis ought never to be preſcribed but in ſmall doſes, as from half a grain to two grains, when they are incorporated with ſolid medicines and in ſmall bulk; but they may be given from one to ſix grains, if they be diluted, on account of their cauſticity, in a pint of ſome watery vehicle. Theſe ſaline ſubſtances are diſſolving, aperitive, and lithontriptic. They are not much employed for theſe qualities; but are principally uſed to correct reſinous purgatives, which they do very well, by giving to theſe medicines a ſaponaceous quality. Externally applied, theſe alkalis are reſolvent, diſcutient, and cauſtic. (o)

XXXIV. ALKALI (VOLATILE). Volatile alkali is a ſaline ſubſtance procured by decompoſition, from all animal, and from ſome vegetable ſubſtances, and by putrefaction from all theſe matters. (p)

This ſaline ſubſtance is called *alkali*, becauſe in fact it has all the general properties of ſaline alkalis, as the ſharp, cauſtic and burning taſte, the property of tinging violets with a green color; of combining with acids to the point of ſaturation, and forming with them different neutral ſalts, moſt of which are cryſtallizable; of ſeparating all earthy and metallic matters from their union with acids; laſtly, of diſſolving by the humid way, almoſt all ſubſtances ſoluble by other alkalis.

(o) Dr. Smith, in a treatiſe *de motu muſculari*, mentions an extraordinary fact which he affirms to have aſcertained by repeated experiments, namely, that of the many ſubſtances which he mentions, acid, alkaline, and corroſive, mineral alkali and compounds formed of it, were alone capable of ſtimulating or irritating the muſcles of frogs, by immediate application to them, which were expoſed for the ſake of making theſe experiments.

(p) The plants from which volatile alkali is obtainable by diſtillation are chiefly of the cruciform kind. This ſalt is obtained by diſtilling all kinds of clays, (as Brandt ſays) many calcareous earths, chiefly that kind called Lapis ſuillus, and ſome mineral waters. Sal ammoniac, which contains volatile alkali, is ſublimed in volcanos. Sal ammoniac may be produced from ſoots of burning vegetable or animal ſubſtances, and even of mineral coal. Authors mention various methods by which volatile alkali may be produced. As a knowledge of theſe may aſſiſt us to form a theory concerning this ſaline ſubſtance, we ſhall relate ſome of them. Volatile alkali may be produced by heat, 1. From a mixture of quicklime with vitriol, or with alum, or with tartar. *Pott.* 2. From a mixture of any eſſential oil with vitriolic acid and fixed alkali. *Id.* 3. From nitre detonating with charcoal. *Id.* 4. From a combination of marine acid with quicklime. *Id.* 5. From magneſia alba by diſtillation. *Dr. Black.* 6. From tartar. *Id.* 7. From deliquiated ſalt of tartar poured on white ſalt of vinegar. *German Ephemerides, Pott, Ludovici, and Hoffman.* 9. From ſea-ſalt combined with putrefying ſubſtances. *Pott.* 10. From ſea-ſalt diſtilled with charcoal. *Id.* 11. From ſea-ſalt diſtilled with quicklime. *Id.* 12. From ſalt of Sylvius diſtilled with fixed alkali. *Beck and Peterman.* 13. From ſea-ſalt diſtilled with clay. *Brandt.* 14. From ruſt of iron diſtilled. *Bourdelin.*

This alkali is called *volatile*, becauſe in fact it is very much ſo. Its volatility is owing to a portion of attenuated, very ſubtle, and very volatile oil, which enters into its compoſition as one of its principles, as is proved by its diſtinguiſhing properties.

Volatile alkali differs according to the ſubſtances whence it is procured, and according to the manner of obtaining it. Theſe differences proceed from ſome principles ſuperabundant and extraneous; particularly, ſeveral oils from which it is not at firſt exactly depurated. But all volatile alkalis, however obtained, and from whatever ſubſtances, may be ſo purified by the method which ſhall be ſoon deſcribed, that no difference remains amongſt them; and hence we ought to conclude of this ſubſtance, as well as we did of the various kinds of fixed alkali, that it is ſingle, identical, and always ſimilar to itſelf, when ſufficiently purified.

Pure volatile alkali differs from fixed alkali, firſt, by its greater volatility, which is ſo great that it may be entirely ſublimed or diſſipated by a heat much leſs than the heat of boiling water; by its ſmell, which is only an effect of its volatility: the ſmell of this ſalt is ſtrong, very penetrating, and ſo pungent, that it cannot be endured above an inſtant, without ſuffocation or fainting; its vapor, excites a cough, and brings tears into the eyes. It is this ſalt which occaſions the pungent ſmell obſerved in neceſſary-houſes at changes of weather.

This alkali differs alſo from the fixed by its leſs force; hence fixed alkalis are capable of decompoſing all thoſe ſalts whoſe baſes are volatile alkali, of ſeparating it from theſe ſalts, and of ſetting it at liberty.

Volatile alkali unites perfectly with water, to which it has even a ſtrong affinity, and with it retains fluidity: it is then called volatile alkaline ſpirit. When it contains no ſuperabundant water, it is in a concrete form, and is cryſtallized, in which it differs from fixed vegetable alkali. (q)

All acids unite and effervеſce with volatile alkali to the point of ſaturation, forming neutral ſalts generally called *ammoniacal ſalts*.

Ammoniacal ſalts have an infinitely ſtronger and more pungent taſte than ſalts whoſe baſes are fixed alkali, becauſe volatile alkali unites with acids leſs intimately. Theſe neutral ſalts are ſemi-volatile; that is, they may be ſublimed by a ſufficiently ſtrong heat; and this property they owe to the volatility of their alkaline baſis.

The ammoniacal ſalt which volatile alkali forms with vitriolic acid is cryſtallizable, and is called *vitriolic ammoniacal ſalt*, or *ſecret ammoniacal ſalt of Glauber*, from the name of the chemiſt who diſcovered it. *See theſe words.*

The kind of nitre formed by volatile alkali and nitrous acid is alſo cryſtallizable, and has the peculiar property of detonating alone, when heated ſufficiently, without addition of any matter containing phlogiſton, as is neceſſary for the detonation of ordinary nitre. This phenomenon proves the exiſtence of the inflammable principle in volatile alkali. This nitre, whoſe baſis is volatile alkali, is called *ammoniacal nitre*, or *nitrous ammoniacal ſalt*. *See theſe words.*

(q) Volatile alkali, by combination with fixable air, is cryſtallizable; uncombined, it cannot be obtained in a ſolid ſtate.

With marine acid, volatile alkali forms alſo a neutral cryſtallizable ſalt, called *Sal Ammoniac.* This is the moſt uſed, and firſt known of the ammoniacal ſalts, and from which the name has been derived to the others. *See* SAL AMMONIAC.

Volatile alkali may be combined with ſulphur, with which it forms a kind of volatile liver of ſulphur, the preparation of which is given by Hoffman. *See* LIVER *of* SULPHUR.

Moſt metallic matters are attacked, and more or leſs diſſolved by volatile alkali; but copper is of all metals the moſt eaſily and copiouſly diſſolved by it. To diſſolve this metal nothing more is requiſite than to digeſt its filings in liquid volatile alkali. The ſolution acquires a beautiful blue color.

This ſolution exhibits a curious and intereſting phenomenon, which is, that if the bottle containing it be well corked, the blue color grows fainter, and at length entirely diſappears, ſo that the liquor becomes colorleſs like water. But if the ſame bottle be then uncorked, the upper part of the ſolution from its contact with the external air reſumes its color, and this color is gradually communicated to the reſt of the liquor. Thus may this blue color be made to appear and diſappear alternately, as often as is required, by corking and uncorking the bottle.

Other metallic matters are not nearly ſo eaſily attacked by volatile alkali as copper is. Theſe ſolutions have even not been much examined.

When metals are previouſly diſſolved and divided by acids, they are then infinitely more ſuſceptible of ſolution by volatile alkali. For this purpoſe it is ſufficient to pour into ſome ſtrong alkaline ſpirit ſome drops of metallic ſolution. At firſt a precipitate is formed, which ſoon diſappears upon agitating the liquor, and is rediſſolved by the volatile alkali. That this experiment ſhould ſucceed, it is neceſſary that the metallic ſolution ſhould have a conſiderable exceſs of acid; that is, that the acid ſhould not be nearly ſaturated with the metal. By this method, copper and mercury are diſſolved in greater quantity than other metals.

In whatever manner the copper be diſſolved by this ſalt, it always communicates a blue color, very beautiful and deep. This property renders the alkaline ſpirit a proof liquor to diſcover copper, and render it ſenſible when it could not, from the ſmallneſs of its quantity, be perceptible by other methods. Thus a little volatile alkali may be poured into any mineral water, containing too ſmall a quantity of copper to be otherwiſe perceptible. The blue color which this water aſſumes diſcovers the preſence of copper.

Volatile alkali, added gradually to a metallic ſolution, ſeizes the acid of the ſolution, and precipitates the metal. The moſt ſingular metallic precipitate made by volatile alkali is that of gold previouſly diſſolved in aqua regia. This precipitate is of a yellow color, and is one fourth part heavier than the gold employed. (*r*) When heated to a certain degree, it detonates and fulminates with a moſt terrible exploſion. It is called *fulminating gold*. *See* GOLD (FULMINATING).

(*r*) Dr. Black, in his Eſſay upon Magneſia, attributes the encreaſe of weight which metallic precipitates gain, to adhering fixable air, which they receive from the precipitating alkalis. To this adhering air he alſo attributes the fulminating property of the precipitate called *Fulminating Gold.*

Mercury diſſolved in ſpirit of nitre, and precipitated by volatile alkali, is of a ſlate color. This color proceeds from the inflammable matter of the volatile alkali. The other metallic precipitates made by volatile alkali have nothing ſingular: none of them fulminates like the precipitate of gold; even that of platina does not, tho' this metal poſſeſſes ſo many of the properties of gold. (s)

Volatile alkali, as well as fixed, acts upon oils, and forms with them different ſaponaceous compounds; hence this ſalt may be employed to ſcour and clean from greaſe; and lixiviums made of quicklime and urine which contain much volatile alkali, are uſed in ſome arts. This alkali is nevertheleſs leſs eaſily united with oils than fixed alkali is, and particular management is neceſſary to bring it to a ſaponaceous ſtate. *See* SPIRIT (VOLATILE AROMATIC OILY); and EAU DE LUCE. Theſe are the principal ſaponaceous compounds made with volatile alkali.

Volatile alkali, when firſt ſeparated from animal and vegetable matters, is, as we before obſerved, very impure. It is particularly depraved by much empyreumatic oil, which is united with it into a ſtate perfectly ſaponaceous, and which it renders ſoluble in water. It may be ſeparated from this ſuperfluous oil by diſtilling it with a very gentle fire, either alone, or mixing with matters capable of abſorbing and retaining the oil, as fixed alkalis and abſorbent earths are. But the moſt efficacious method of purifying it is, to reduce it to ſal ammoniac, and then to decompoſe this ſalt, by any of the proper mediums for the diſengagement of the volatile alkali. By this method it is obtained in its greateſt purity; becauſe, in its combination with the acid, it perfectly ſeparates itſelf from all extraneous matter. *See* SAL AMMONIAC, *for the purification of volatile alkali, and for ſeveral of its eſſential properties.* (t)

The affinities of volatile alkali, according to Mr. Geoffroy's table, are, vitriolic acid, nitrous acid, and marine acid. According to Mr. Gellert's table they are, phlogiſton; vitriolic, nitrous, and marine acids; vinegar; zinc; iron; copper; biſmuth; mercury; ſilver; and gold.

(s) From Mr Margraaf's Experiments, publiſhed in the Berlin Memoirs for the year 1745, we find that gold, ſilver, biſmuth, zinc, and copper, diſſolved in their proper acid ſolvents, may be firſt precipitated from theſe, and afterwards rediſſolved by volatile alkali; that theſe metals precipitated by fixed alkalis may be again diſſolved by volatile alkali; and that mercury, lead, and tin, were not diſſolved by volatile alkali applied in the ſame manner. Brandt ſays, that volatile alkali occaſions a coagulation of a ſolution of iron in nitrous acid, which is ſoon rediſſolved; and that the ſame alkali precipitates iron from vitriolic acid. He alſo ſays, that regulus of cobalt cannot be precipitated from nitrous acid, nor arſenic from aqua regia, by volatile alkali. Volatile alkali has no effect upon any metal not previouſly diſſolved by acids, excepting copper, iron, and lead; the firſt of which it diſſolves perfectly, a very ſmall quantity of the ſecond, and the third is very ſlowly changed by it into a kind of mucilage. See POTT *ſur la Diſſolution des Corps.*

(t) To the properties above-mentioned of volatile alkali, we may add, 1. That pure or cauſtic volatile alkali, that is, uncombined with fixable air, or the ſpirit of ſal ammoniac obtained by quicklime, is ſoluble in ſpirit of wine, and that mild volatile alkali is not ſoluble in that ſpirit; hence if a ſtrong ſolution of mild volatile alkaline ſalt be added to ſpirit of wine, the water of the ſolution will combine with the ſpirit, and the ſalt will be precipitated, forming what is called *Offa Helmontii*. 2. Mild volatile alkaline ſalt requires four times its quantity of water to diſſolve it: cauſtic volatile alkali, as we have already obſerved, is always combined with water. 3. Volatile alkali deflagrates with nitre, which proves that it contains an inflammable matter.

Volatile alkali is employed in medicine as a powerful ſtimulant and exciter, when applied ſo that the perſon ſhall inhale the vapors of it. Thus it is applied in faintings, ſyncopes, apoplexies, and in all lethargic diſeaſes, in which the nervous parts are benumbed and unbraced. In theſe caſes it is uſually applied in bottles, either in a concrete form called *Engliſh Salt*, or in a fluid form, and reduced to a ſemi-ſaponaceous ſtate by mixture with oil of amber, when it is called *Eau de Luce*. *See* Salt (English); and Eau de Luce.

It may alſo be taken internally in theſe caſes, particularly in apoplexies and lethargic diſeaſes, but in ſmall doſes, as from two or three grains to ſix, and added to ſtimulant mixtures. Taken in this manner, it ſometimes is a powerful ſudorific.

M. Bernard de Juſſieu has diſcovered that this ſaline ſubſtance is a ſpecific againſt the bite of vipers; having cured as it were miraculouſly, by means of eau de luce, a ſtudent of medicine, to whom this accident happened, while he was botanizing.

XXXV. ALKALISATION. This name is applied to operations by which alkaline properties are communicated to bodies; or to thoſe by which alkali is extracted from bodies which contain it, or in which it may be formed. For example, *ſpirit of wine* is ſaid to be *alkaliſed* when it has been digeſted upon alkali, a part of which it diſſolves, and thence acquires alkaline properties. On the other hand, when a neutral ſalt is decompoſed in order to obtain its alkaline baſis, this ſalt is ſaid to be alkaliſed. Thus nitre, deprived of its acid by detonation with inflammable matters, as charcoal, tartar, metals, ſo that nothing remains but its alkali, is called *Nitre alkaliſed by Charcoal*, or *by Tartar*, &c.

Vegetable ſubſtances, when reduced to aſhes, may alſo be ſaid to be alkaliſed; becauſe theſe aſhes contain fixed alkali. *See* the detail of particular alkaliſations, under the articles of the different Alkalis.

XXXVI. ALKOHOL. This name has been given to any impalpable powder. *See* Porphyrisation.

It has alſo been given to highly rectified ſpirit of wine. *See* Spirit *of* Wine.

XXXVII. ALLAY. This word is employed in chemiſtry to ſignify the union of different metallic matters.

As an infinity of different combinations may be made according to the nature, the number, and the proportions of the metallic matters capable of being allayed, we ſhall not here enter into the detail of the particular allays, all which are not yet nearly known. Thoſe which are uſed, as *Bronze*, *Tombac*, *Braſs*, *White Copper*, &c. may be found under their particular names; and what is known concerning other allays may be partly found under the names of the different metals, and ſemimetals, and partly in this article.

Metallic ſubſtances cannot unite directly with earthy matters, not even with their own earths, when deprived of their inflammable principle, and conſequently of their metallic properties. But in general it may be ſaid, that all metals may be allayed with each other, although more or leſs eaſily, and although ſome of them have not yet been made to unite.

As metals are bodies naturally ſolid, the firſt condition for their union is, that they be fuſed. They then unite, like all bodies which reciprocally diſſolve each other; and from theſe combinations new compounds reſult, which have the mixt properties of the component ſubſtances. *See* Composition (Chemical).

In theſe metallic allays, as in almoſt all other metallic combinations, phenomena appear which depart from the general rules of combinations. Thus it is obſerved, that ſome of the properties of metals forming an allay are altered, encreaſed, or diminiſhed by their union. The ductility, for inſtance, of a metallic compoſition is generally leſs than the ductility of the component metals alone and pure. The denſity or ſpecific gravity of metals and ſemimetals is alſo changed by allaying them with each other. Sometimes the ſpecific gravity of the compound is intermediate betwixt the ſpecific gravity of the component metals, ſometimes it is leſs, and frequently greater: this depends upon the nature of the metals. The ſame obſervation may alſo be applied to the colors reſulting from the allays of metals.

Metallic allays are either *natural* or *artificial*. The firſt are thoſe made by nature, ſuch as moſt minerals, containing ſeveral metals allayed with each other. Native gold is always more or leſs allayed with ſilver; and native ſilver with gold.

Artificial allays are thoſe made expreſly for different uſes, or for the ſake of examining their properties.

Although the allays of different metallic matters are of great importance to the theory and to the practice of chemiſtry, yet all the reſearches which the ſubject deſerves, and is capable of, have not been made. Mr. Gellert is one of thoſe who have done moſt in this way. In his *Metallurgic Chemiſtry* there are a great number of experiments, which we ſhall relate here ſummarily. The experiments made for the allaying of ſemimetals with metals are his own, and were undertaken to determine the ſpecific gravities of theſe allays. He relates the others before known, from chemical writings, and particularly from a Diſſertation of Mr. Kraaft expreſly on this ſubject. We ſhall refer the allays of mercury with other metals, called Amalgams, to the word AMALGAM.

Gold may be eaſily united with ſilver, and in all proportions. Mr. Gellert ſays, that this allay is nearly of an intermediate gravity betwixt the gravities of the two metals, and but a very little augmented. This allay is of no uſe in the arts: on the contrary, as pure metals are always more ductile than allays, in the arts where ductility is requiſite, as in wire-drawing, gold-beating, the pureſt metals are choſen. (*u*)

Silver may be eaſily allayed with copper, and in all proportions: copper alſo unites in the ſame manner with gold. Gellert obſerves that the allay of ſilver

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(*u*) The component metals of which metallic allays are formed may be either chemically combined, that is, mutually diſſolved by each other; or mechanically mixed, that is, diffuſed through each other by the action of fire; or they may be partly combined, and partly diffuſed, if the proportion of their quantities to each other be different from that which is neceſſary for their combination. For moſt, if not all, metals can be only combined with each other in certain proportions, as is very obſervable in thoſe, the fuſion of which requires very different degrees of heat. But thoſe which may be kept fuſed in nearly the ſame degrees of heat may be mixed together in almoſt any proportion, and will be nearly uniformly diffuſed throughout the metallic maſs when haſtily cooled. As metallic allays have not been before conſidered in this manner, no experiments have been made to determine the proportions with which they can combine; nor can we eaſily eſtabliſh rules by which this kind of combination can be aſcertained. Thoſe, however, which appear to me moſt probable, for diſtinguiſhing this combination, are, 1.

and copper is of a greater than the intermediate gravity; but that the allay of gold and copper is of a gravity leſs than intermediate. Copper renders gold and ſilver harder and more ſonorous, without much diminution of their ductility. It has even the remarkable property of rendering theſe two metals leſs ſuſceptible of loſing their ductility by the vapor of charcoal, which they are very liable to do; copper alſo heightens the color of gold. Theſe properties of copper relatively to gold and ſilver render its allay with theſe metals of great uſe to gold and ſilver-ſmiths; becauſe it makes them firmer, and fitter for working and chaſing; and alſo for making money, for the ſame reaſons; and for the payment of the Prince's duties, and for compenſation of the expences of coining. The quantity of copper allayed with gold and ſilver for theſe different uſes varies according to the different countries, but in each country it is fixed, and always the ſame.

Iron allays well with ſilver, and ſtill better with gold. Gellert obſerves, that the gravity of an allay of gold and iron is leſs than the intermediate. The affinity of theſe two metals is very great; for gold facilitates its fuſion, which indi-

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When an allay poſſeſſes properties which neither of its component metals had. 2. When the properties, as the ſpecific gravity, color, hardneſs, &c. of the allay, are not in an intermediate degree betwixt the ſame properties of the component metals, according to the proportion of theſe metals to each other. 3. When the component parts of an allay are not ſeparable from each other by eliquation; that is, by applying a heat capable of fuſing one of them only; nor by keeping the whole maſs in fuſion, with a heat not more intenſe than is neceſſary for that purpoſe, but inſufficient to occaſion an ebullition, and by cooling the melted maſs very ſlowly. When therefore, according to theſe rules, a metallic allay has no properties but thoſe which its component metals had; when its denſity, color, hardneſs, elaſticity, fuſibility, and other properties, are preciſely in an intermediate degree betwixt thoſe of its component metals; and laſtly, when its component metals may be ſeparated from each other by eliquation, or by giving them ſuch a fluidity and reſt as that they may ſeparate according to their reſpective denſities; we may then, with probability, pronounce that this allay is compoſed of parts not chemically combined: and when to an allay, which by theſe rules is compoſed of metals chemically combined, a quantity of one of the ſame kinds of metal of which the allay is compoſed, be added, and, upon examination, the new allay be found to poſſeſs no properties but ſuch as are intermediate betwixt the firſt allay and the added metal, and to be ſeparable by eliquation, or by their different denſities, we may then conſider this new allay as a maſs conſiſting of metals partly combined, and partly diffuſed. That the allay mentioned in that part of the text to which this note refers, namely, that of gold with ſilver, does not conſiſt of parts chemically combined, or elſe that but a very ſmall proportion of each of theſe metals can be combined with the other, appears probable from the following reaſons. 1. The denſity of the allay is very nearly intermediate between the denſities of the component parts. 2. The ſilver and gold are not uniformly and equally diſtributed through the whole maſs. This inequality is proved by an experiment of Mr. Hellot. He melted a maſs of 20 pounds, containing 55 parts of ſilver and one part of gold, and poured it into three ſeparate maſſes, each of which was found by eſſay to contain a different proportion of gold from the two others. 3. Gold and ſilver kept in gentle fuſion are ſeparable from each other, merely by their different denſities. Mr. Homberg kept equal parts of gold and ſilver in gentle fuſion a quarter of an hour, and found, upon breaking the crucible, two maſſes, of which the upper was pure ſilver, and the lower the whole gold allayed with $\frac{1}{6}$th part of ſilver. He repeated the experiment with nearly the ſame event; and twice he obtained the two metals perfectly ſeparated from each other. *See a note to the article* AFFINITY.

cates a ſtrong diſpoſition to unite. Gellert obſerves upon this occaſion, that therefore gold is fitter than copper for ſoldering fine works of iron and ſteel. (*w*) Iron unites difficultly with copper, and in ſmall proportion. It renders copper paler. The portion of iron which does not unite with copper forms a ſeparate regulus, which, however, ſtrongly adheres to the ſurface of the regulus of copper. The degrees of affinity of iron with other metals, according to Gellert's table, but reverſing the order in which he has placed them, (that is to ſay, beginning by thoſe with which it has the ſtrongeſt affinity, which ſeems to be the moſt natural order) are, gold, ſilver, and copper.

Tin, according to the ſame author, unites with all metals, and renders them brittle; iron and lead it alters leaſt in this reſpect. (*x*) But gold and ſilver are ſo affected by tin, that its vapor alone is capable of deſtroying the ductility of a large quantity of theſe metals, as is well known to artificers.

The allay of tin with gold and ſilver is then of no uſe; on the contrary, it is carefully avoided; but with copper tin forms an uſeful compound, known by the name of *Bronze.* The ſpecific gravity of allays of ſilver and of copper with tin is greater, and that of gold with tin is leſs than the intermediate. The affinities of tin with other metals, according to Gellert's table, (only reverſing his order, which we ſhall always do) are iron, copper, ſilver, gold.

Lead unites with all metals, excepting iron, with which no method has been found to unite it. Gellert obſerves, that this property of iron with regard to lead renders it fit to ſeparate this latter metal from others, provided that the metal from which it is to be ſeparated has not a greater diſpoſition to unite with lead, than the iron has to unite with it. This is certain, that lead may ſerve as an intermedium by which iron may be ſeparated from other metals: for inſtance, from ſilver. For if a ſufficient quantity of lead be melted with ſilver allayed with iron, it will eaſily ſeize upon the ſilver, and ſeparate the iron from it, which will then ſwim upon the ſurface of the two melted metals.

The allays of gold and of ſilver with lead have a greater ſpecific gravity, and the allays of copper and of tin with lead have a leſs ſpecific gravity, than the intermediate.

The allay of lead with other metals is uſed for the eſſays of ores, for refining, and for liquation. *See* LIQUATION.

Lead and tin are allayed together to form a ſolder for pipes and other works of lead.

The affinities of lead with other metals, according to Mr. Gellert's table, are, ſilver, gold, tin, copper.

Zinc may be allayed with all metallic matters, excepting biſmuth, with which it cannot unite, according to Mr. Gellert. This ſemimetal, when united with metallic ſubſtances, gives fuſibility to thoſe which are leſs fuſible than itſelf. The denſity of allays of gold, of ſilver, of copper, and of lead with zinc is greater; and that of allays of the ſame ſemimetal with tin, iron, and regulus of antimony, is leſs than intermediate.

(*w*) A very ſmall quantity of iron renders gold hard, brittle, and pale. So hard are ſome mixtures of iron and gold, that they are ſaid to have been formed into razors. Three or four parts of iron and one part of gold compoſe an allay nearly as white as ſilver.

(*x*) Equal parts of tin and iron form a white but brittle maſs.

The allays of zinc with moſt metallic matters are not uſed in the arts, but that with copper is very much. This allay forms *Braſs*, *Tombacs*, *Prince's Metal*, *Pinchbeck*, &c.

The affinities of zinc with other metallic matters are, according to Gellert's table, copper, iron, ſilver, gold, tin, lead *partly*; that is, it does not unite with lead in all proportions.

Biſmuth unites with all metals, and with moſt ſemimetals. It has ſo great action upon other metallic ſubſtances, that it ſenſibly facilitates their fuſion. (y) Biſmuth renders all the metals with which it is united brittle. It does not unite with zinc; nor, according to Mr Gellert, with arſenic. When melted along with zinc, it remains at the bottom of the crucible, as being the heavier of the two; and when they are cooled, they are found forming two diſtinct reguli adhering ſtrongly to each other. Gold, ſilver, lead, and regulus of antimony form with biſmuth allays of greater, and iron forms an allay of leſs, than intermediate denſity, and copper forms with it an allay of intermediate denſity.

The allays of biſmuth are not in uſe, excepting ſome particular metallic compoſitions for mirrors.

The affinities of biſmuth with other metals are, according to Mr. Gellert's table, in the following order: iron, copper, tin, lead, ſilver, gold.

" Cobalt" *, ſays Mr. Gellert, " may be allayed with all metals and ſemimetals; but it acts little upon lead and ſilver. When equal parts of lead and
" cobalt are melted together, theſe two ſubſtances are found only adhering to
" each other, the lead being, in conſequence of its greater ſpecific gravity, at
" the bottom of the crucible, and the cobalt above it; ſo that it ſeems probable that they are not at all combined. But if the ſame cobalt be melted,
" after it has been thus treated, with iron, which ſeems to be the moſt readily
" united with it of all the metals, a ſmall regulus of lead is found at the bottom
" of the crucible, becauſe iron and lead do not unite. At firſt, we might be
" apt to believe that ſilver and cobalt do not unite together. In fact, if two
" parts of cobalt, and one part of ſilver be melted together, the ſilver is found
" at bottom and the cobalt above, only adhering to each other: But the ſilver
" is become more brittle, of a greyiſh color; and the cobalt is become whiter
" than before. If this ſilver be cupelled, the part of the cobalt united with it
" will attach itſelf to the cupell in form of a circle, and the ſilver will be found

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(y) Biſmuth greatly encreaſes the fuſibility of ſome metals, as appears from the following table of Dr. Lewis, in which the degrees of heat are marked in numbers according to Fahrenheit's ſcale.

600. Mercury boils.
540. Lead melts.
460. Biſmuth melts.
410. Tin melts.
390. Tin 8 parts, biſmuth 1 part, melt.
330. Tin 2 parts, biſmuth 1 part, melt.
Tin 3 parts, lead 2 parts, melt.
280. Tin and biſmuth, equal parts, melt.
212. Water boils.

An allay compoſed of two parts of lead, three parts of tin, and five parts of biſmuth, may be melted with conſiderably leſs heat than the moſt fuſible of thoſe mentioned in the above table.

* Note. By *Cobalt* Mr. Gellert certainly means what we call Regulus of Cobalt; for Cobalt properly called is a mineral compoſed of other ſubſtances beſides the regulus of cobalt, as ſulphur, arſenic, biſmuth, ſilver, and unmetallic earths. *See* COBALT.

“ to have loſt an eighth part of its weight, which will be found upon eſſaying “ the cobalt, and examining how much ſilver it contains.” *Metallurgic Chemiſtry, Tom.* I.

Theſe experiments of Mr. Gellert's prove, that regulus of cobalt cannot be united to lead and to ſilver in all proportions, but only in ſmall quantity. The ſame may be ſaid of biſmuth, with which, ſays Mr. Gellert, cobalt is very eaſily united: for Mr. Beaumé, who has made many experiments on the regulus of cobalt, has obſerved, that when this regulus is melted with biſmuth, theſe two metals are found ſeparate, the biſmuth being at the bottom of the crucible and the cobalt above it.

The allays of the regulus of cobalt are but little known, and not uſed in the arts.

In Mr. Gellert's table the affinities of regulus of cobalt with metallic matters are in the following order: copper, iron, tin, zinc, regulus of antimony, biſmuth and lead, ſilver, and arſenic, partly.

Regulus of antimony may be allayed with almoſt all metallic ſubſtances. Mr. Gellert ſays, that the denſity of allays of this regulus with iron, tin, or zinc, is leſs than intermediate, and that the denſity of allays of this regulus with ſilver, copper, lead, and biſmuth, is greater than intermediate. He obſerves alſo, that the magnetic property of iron is much more diminiſhed by an alſay of that metal with regulus of antimony than with any other metallic ſubſtance.

Allays of regulus of antimony are little uſed in the arts. It is uſed for ſome compoſitions for ſpeculums. An allay of this ſemimetal with iron, tin, and copper, is made for the preparation of a medicine called *Lilly of Paracelſus*, or *Tincture of metals. See* LILLY *of* PARACELSUS.

The affinities of the regulus of antimony with metallic ſubſtances are placed by Mr. Gellert in the following order: zinc, copper, tin, lead, ſilver, gold. Biſmuth is ſo placed in the table as to denote its incapacity of uniting with the regulus of antimony.

Arſenic, or its regulus, unites with moſt metallic matters. Mr. Gellert ſays, that it whitens iron; but the allay reſulting from thence is very brittle. Copper is alſo rendered very white by mixture with arſenic. This is the *white tombac* which reſembles ſilver. Mr. Gellert affirms, that this allay, notwithſtanding it contains arſenic, is ſufficiently ductile and malleable, which is very remarkable. But if it contain too much arſenic, it is brittle, and blackens in its ſurface. Arſenic united with tin is partly reduced to a powder like aſhes, in which much arſenic remains. The reſt of the tin is very brilliant, foliated, and externally reſembling zinc, without being poſſeſſed of any of its properties. Tin alſo becomes much harder and more ſonorous by this union. Lead united with arſenic ſmokes and ſwells more quickly with a moderate fire than it does alone: a part of it is diſſipated in form of a thick ſmoke; another part is changed into a glaſs of a reddiſh yellow color; and the remaining lead is brittle, and dark-colored. Arſenic unites with ſilver, and renders it brittle. It does the ſame to gold, and alſo deprives it of its color, rendering it pale. It unites very difficultly with cobalt, with which it forms a black, ſhining matter. Laſtly, Mr. Gellert (from whom all this is extracted) ſays, that biſmuth cannot be united with arſenic.

In this author's table of affinities, the metallic ſubſtances capable of uniting with arſenic are placed in the following order, which is the ſame as that for the regulus of antimony: zinc, iron, copper, tin, lead, ſilver, gold, regulus of antimony.

The allays of arſenic uſed in the arts are white tombacs, and ſome compoſitions for ſpeculums.

It is neceſſary to remark on the ſubject of arſenical allays, that this ſingular ſubſtance has the property of uniting with metals even when deprived of phlogiſton, and in an unmetallic ſtate. This proceeds from its ſaline character, and from its property of taking phlogiſton from the imperfect metals and from the ſemimetals; conſequently there ought to be a difference betwixt the allays made with white cryſtalline arſenic, and thoſe made with the regulus of arſenic. *See* ARSENIC, and REGULUS *of* ARSENIC. (z) It is proper to obſerve, that chemiſts who treat of metallic allays differ much from each other in the deſcriptions they give of the reſults of their experiments, as may be ſeen in the particular articles of each metallic matter, which ought to be conſulted on this ſubject. But theſe varieties are not ſurpriſing, when we conſider the difficulty of the matter, and the great obſtacles which prevent perfect exactneſs in theſe experiments. All who have operated much in chemiſtry will eaſily perceive, that, without reckoning the difference of proportions of the metals employed in the allays, which muſt greatly affect the reſults, others much more conſiderable would occur, depending on the purity of the metals, on the greater or leſs quantity of phlogiſton with which many of them are capable of being united, on the very variable deſtructibility and volatility of many metallic matters, and laſtly, on the juſt degrees of heat, which are of conſiderable conſequence, and which it is almoſt impoſſible to determine preciſely.

From theſe obſervations we ought to conclude, that, in order to make a ſet of accurate experiments on metallic allays, and which may be depended upon, it is, in the firſt place, neceſſary that all the metallic matters to be employed be exceedingly pure, which is a matter of great difficulty: in the ſecond place, it is proper to make all the fuſions in veſſels perfectly cloſe, to prevent the alteration, the burning, and the deſtruction of thoſe metals which are liable to thoſe events: laſtly, to determine carefully the preciſe degree of heat requiſite for the beſt combination of metallic matters with each other. But it does not appear that any perſon has hitherto done this great and important work; it is to be wiſhed that it was undertaken. How many fine experiments may then be made upon all theſe allays, to diſcover their properties!

What has been already done in this matter is, however, ſufficient to eſtabliſh ſome general truths. Several have been explained in the beginning of this article. Another evidently reſults from the experiments of M. Kraaft and M. Gellert: it is this, That as the union of all other bodies, ſo in that of metallic ſubſtances, ſome are more eaſily ſoluble, and in all proportions, others more or leſs difficultly, and only in certain proportions; and laſtly, others appear incapable of uniting in any manner.

(z) The author of the Dictionary has omitted, in the enumeration of allays, thoſe of platina, and of the ſemimetal diſcovered by Mr. Cronſtedt, called *Nickel*. For thoſe of platina, *ſee* the article PLATINA. *Nickel* may be allayed with all metallic ſubſtances excepting ſilver, mercury, and zinc. By means of nickel the two ſemimetals biſmuth and regulus of cobalt may be united. It whitens copper and gold, and it renders the malleable metals hard and brittle.

On theſe two latter caſes it is very important to obſerve, that this property which certain metallic matters have of diſſolving others in certain proportions only, is very capable of impoſing on the operator, and of perſuading him that one metal cannot be united with another, becauſe he ſees after the fuſion two diſtinct reguli, while in fact there is a quantity, though frequently a very ſmall one, of one of the metals united with the other. This is ſimilar to what happens in the combination of ſpirit of wine with oils, and of water with ether. Chemiſts believed long that ether was inſoluble in water, becauſe when theſe two liquors were put in the ſame veſſel they conſtantly ſeparated, the ether, being greatly the lighter of the two, riſing upwards, and floating on the ſurface of the water. But the Count de Lauragais, having examined the matter more attentively, and in a truly chemical manner, demonſtrated, in a memoir read at the Academy of Sciences, of which he is a member, that ether is really ſoluble in water, but only in a certain proportion. *See* ETHER. This being eſtabliſhed, perhaps we ſhould find, if we were to examine all the mixtures of metallic ſubſtances, that thoſe which have hitherto been conſidered as incapable of union are, nevertheleſs, very capable of it, but only in certain proportions; and if ſome are found which cannot by ordinary fuſion be united, we might ſtill try to break their aggregation more compleatly, and to apply them to each other in this condition, as the Count de Lauragais has done with ſulphur and ſpirit of wine. *See* COMBINATION; COMPOSITION (CHEMICAL).

XXXVIII. **ALUDELS.** Chemiſts give this name to certain pots or capitals which are open at both the upper and lower ends, and may be inſerted and applied above each other, ſo that the whole ſhall form a pipe or tube more or leſs long according to the number of aludels compoſing it. The aludel which terminates this tube above ought to be cloſed in its upper part, or to have but a very ſmall opening. The tube compoſed of theſe aludels is nothing but a kind of capital or head, which may be enlarged or lengthened at pleaſure, and adapted to a cucurbit. This apparatus is intended to collect and retain dry and volatile matters, which may be reduced into flowers by ſublimation. It may be employed for the preparation of flowers of ſulphur, of arſenic, of antimony, of benjamin, &c. *See* SUBLIMATION. *See alſo* PLATES.

XXXIX. **ALUM.** Alum is a cryſtallizable ſalt compoſed of vitriolic acid united with an argillaceous earth. This ſalt has an auſtere, ſweetiſh, and ſtrongly aſtringent taſte. This ſtrong taſte proceeds from the ſtrength of union betwixt the acid and its baſe being leſs than in other vitriolic ſalts with earthy baſes; ſuch, for example, as ſelenites, which has no ſenſible taſte. Mr. Beaumé has even obſerved, that the acid of alum is not exactly ſaturated; for it is certain that it reddens turnſol and blue paper.

This ſalt diſſolves ſufficiently well in cold, but in much larger quantity in boiling water. (a) It is conſequently ſuſceptible of cryſtallization by the evaporation and cooling of the water in which it is diſſolved. The figure of the cryſtals of this ſalt varies, like that of other ſalts, according to the circumſtances concurring during the cryſtallization. When its ſolution, evaporated to the cryſtallizing point, is made to cool ſlowly, the greateſt part of its cryſtals are found to be triangular pyramids, whoſe four angles ſeem cut off. Alum retains half its weight of water in cryſtallizing.

(a) Neuman ſays, that alum requires ten times, and other authors ſay requires fourteen times, its weight of water to diſſolve it.

This great quantity of water in the cryſtals of alum, together with its property of greater ſolubility in hot water, is the cauſe that when put in an earthen or iron veſſel, on a good fire, it enters into a liquefaction, which gradually diminiſhes as the water evaporates. When it is entirely evaporated, which is not ſoon, the alum which had ſwelled much during this operation, remains dry and friable; it is then called *Calcined Alum*. After this evaporation, it may be again diſſolved in water, and cryſtallized as before.

Although the acid of alum appears, as its taſte and ſolubility indicate, to be leſs intimately combined with its baſis than the acid of ſelenites, yet but a very ſmall quantity of it can be diſengaged by the ſtrongeſt fire. Mr. Geoffroy put ſome calcined alum into an earthen retort, and expoſed it to a moſt violent fire continued during ſix days and ſix nights; and from five pounds of alum thus treated he obtained only three ounces of vitriolic acid, although it is certain that this ſalt contains a much greater proportion of acid, as we ſhall ſoon ſee. The acid thus obtained by diſtillation from alum is called *Spirit of Alum*; and does not differ from pure vitriolic acid.

Alum may be eaſily decompoſed by ſeveral intermediate ſubſtances.

Firſt, as the acid of alum is certainly the vitriolic, all ſubſtances which have a greater affinity than earths to vitriolic acid, are capable of uniting with it, and of ſeparating from it its earthy baſis.

Alum, therefore, treated properly with any matter containing phlogiſton, may be decompoſed; its acid uniting with it, and forming artificial ſulphur. *See* SULPHUR.

It is by means of this artificial ſulphur, which forms during the calcination of alum with any vegetable or animal matter, that the *pyrophorus of Homberg* is made, which has the property of burning merely by contact of air. *See* PYROPHORUS.

In the ſecond place, all ſaline alkalis are capable of decompoſing alum. This decompoſition may be made in the humid way. If then any alkali be added to a ſolution of alum, the liquor immediately becomes turbid and white, and a ſediment is formed, which is the earth of alum ſeparated from its acid by the intervention of alkaline ſalt. On the other ſide, the new ſalt formed by the union of the acid of alum with the alkali, may be cryſtallized by evaporating the liquor. If fixed vegetable alkali was employed for this precipitation, vitriolated tartar is formed: if mineral alkali was employed, Glauber's ſalt is formed. This decompoſition of alum is a very convenient method of preparing theſe two ſalts. Laſtly, if volatile alkali be employed for this precipitation of the earth of alum, vitriolic ammoniacal ſalt will be formed.

Calcareous earths, and even ſome metallic ſubſtances, are capable of decompoſing alum. The former are ſo, becauſe their affinity is greater than that of the argillaceous earth of alum with the vitriolic acid; and the latter, for inſtance iron and zinc, are ſo, becauſe of the ſlight adheſion of their phlogiſton.

It appears that Mr. Geoffroy was the firſt who diſcovered that iron could decompoſe alum; and this he did by boiling alum in an iron pot. This experiment of Mr. Geoffroy is found in the Memoirs of the Academy of Sciences.

What has been ſaid concerning theſe different decompoſitions of alum proves inconteſtably, that the acid of this ſalt is the pure vitriolic; and this truth has been known a conſiderable time; but till lately, the nature of the earthy baſis of alum was not preciſely and diſtinctly underſtood. For a long time it was conſidered by chemiſts as a calcareous earth: but accurate experiments have ſince ſhewn, that calcareous earths, united with vitriolic acid, formed ſelenites and not alum, which are entirely different; and that the earth of alum could not decompoſe ſal ammoniac, nor be converted into quicklime, nor had any of the diſtinguiſhing properties of calcareous earth. Theſe experiments have been made by Pott, Margraaf, and Baron. This laſt chemiſt, ſtruck with the differences betwixt earth of alum and calcareous earth, and with the reſemblance betwixt alum and moſt vitriolic ſalts with metallic baſes, has given a Memoir to the Academy of Sciences, in which he conjectures that this earth of alum is of metallic nature.

On the other ſide, there were experiments which prove, that the earth of alum was contained in clays. Mr. Geoffroy and Mr. Hellot had ſaid, that, by digeſting clays with vitriolic acid, they had obtained ſalts of the nature of alum. Hellot, having employed a clay as an intermediate ſubſtance in the diſtillation of the ether of Frobenius, perceived that the vitriolic acid of this mixture had deprived the clay of all its argillaceous properties, by taking from it an earth, which being again ſeparated from this acid by an alkali, had all the properties of pure clay. *See Memoirs of the Academy for the year 1739.* Mr. Pott, who quotes in his Lithogeognoſia this experiment of Mr. Hellot, having ſatisfied himſelf with regard to the properties of the alum obtained by digeſting vitriolic acid upon clay, had concluded that the earth of alum is of an argillaceous nature. *See Pott's Lithogeognoſia.* Mr. Gellert in his Metallurgic Chemiſtry, and eſpecially Mr. Margraaf, in three diſſertations upon alum, had mentioned the ſame experiments, and had drawn from them the ſame concluſions. Laſtly, Mr. Macquer, in a Memoir read at the Academy in 1762, *concerning clays and their fuſibility when joined to calcareous earth,* after having quoted the above citations, which are extracted from that memoir, places the affair beyond doubt, by adding his own experiments and obſervations to thoſe already made. I add," ſays this chemiſt, " to all theſe teſtimonies, that having made an accurate examination of the properties of the earth of alum, ſeparated from every acid, I am convinced, by all the proofs to which I have ſubmitted it, that it has an entire and perfect reſemblance to the pureſt clay: that is, to clay perfectly ſeparated from vitriolic acid and all ſandy matter. I have obſerved, that earth of alum, properly prepared, has all the argillaceous properties attributed to it by the above-mentioned chemiſts, and particularly a very binding quality. I have alſo obſerved, that this earth is very difficultly dried, and that it ſtrongly retains the laſt portions of moiſture. By drying, its bulk is conſiderably diminiſhed, which occaſions it to be much cracked. It receives a poliſh, like all fat clays, when rubbed with a ſmooth body. If it be expoſed ſuddenly to fire before it be perfectly dried, it decrepitates ſtrongly, and burſts with great noiſe, like clays. When it has been gradually heated, and then expoſed to a violent fire, I have obſerved that it has acquired a flinty hardneſs, and that by this baking and hardening in the fire it has contracted to one half in all its dimenſions.

“ Notwithſtanding this hardening, and great contraction of its ſize by fire, it is remarkably refractory. It reſiſted the greateſt violence of fire that I was able to expoſe it to without ſhewing the leaſt tendency to melt. Having mixed it with fritts of cryſtal-glaſs, and different fluxes, ſuch as fixed alkaline ſalts, nitre, borax, glaſs of lead, I have found that theſe matters melted and vitrified, without melting this earth; ſo that it has always communicated an opacity to all the glaſſes reſulting from theſe mixtures.

“ A very remarkable property of this earth, but which, like the foregoing properties, is common to it with clays, particularly when very pure, is, that though its color be very white, yet this whiteneſs cannot be preſerved: for when it is moiſt it greedily abſorbs all greaſy, and conſequently coloring particles from contiguous bodies. When expoſed to moderate fire, it begins to blacken; then it becomes more or leſs white, according to the nature of its coloring matter: but to whiten it thus, it ought not to be entirely cloſed, but to have a free communication with external air. Laſtly, if the fire be encreaſed ſufficiently to harden well and bake this earth; then in whatever manner, and with whatever attention it may have been prepared, it never fails to reſume ſo much more color as it is heated more intenſely. It takes all ſorts of tints, yellowiſh, greeniſh, bluiſh, grey, brown; and ſome I have ſeen become quite black. I have already obſerved, that the ſame thing happens to natural clays, when well deprived of ſand.

“ This property denotes a very great diſpoſition in this earth of uniting with the principle of inflammability, and of retaining it ſtrongly when once united. This may give occaſion to conjecture that the earths of metals, and thoſe which are diſpoſed to metalliſation, are eſſentially of argillaceous nature; and this idea adds a new probability to the opinion of Mr. Baron, who, in a memoir upon the earth of alum, conjectures that this earth is of metallic nature, although not really reducible into metal, at leaſt by any proceſſes hitherto aſcertained, and ſufficiently known.

“ However that be, it appears well aſcertained by the chemical experiments quoted above, and by mine, that earth of alum is a pure clay, free from all mixture of vitreſcible earth; and that all natural clays are mixtures of greater or leſs quantities of this pure argillaceous earth, which is capable of combining with vitriolic acid, and of forming with it alum; and of another ſubſtance of different nature, which in its natural ſtate cannot combine with vitriolic acid, and which Mr. Margraaf conſiders as a true ſand, as indeed it has all the marks of that kind of earth.

“ From all this it may be inferred, that in all natural clays there is only this portion capable of forming alum with a vitriolic acid, which is a true argillaceous earth; and that the other portion is of a nature entirely different.” *See* CLAY.

Alum is capable of decompoſing nitre and common ſalt, in conſequence of the vitriolic acid it contains. The nitrous and marine acids may even be obtained more pure by means of alum than of any other ſubſtance.

All the alum which is in commerce is extracted by different operations from ſeveral pyritous, earthy, or ſtony matters, containing the vitriolic acid and the earth proper for forming this ſalt.

The pyrites or pyritous matters from which alum is extracted, ought to have effloreſced in open air, or to have been calcined in the fire, to allow the vitriolic acid of the ſulphur which they contain to diſengage itſelf. This acid meeting in the pyrites itſelf the argillaceous earth proper to form alum, does in fact there combine with it and form that ſalt; which is afterwards extracted by lixiviation, evaporation, and cryſtallization, as is practiſed for all ſalts. Much of theſe pyrites or pyritous ſtones furniſhing alum are found in Sweden, England, Germany, and France, and they are worked by the general proceſſes we have mentioned. But to have a clear idea of what paſſes in theſe operations, it is neceſſary to know pyrites, and its nature; for which reaſon ſee the word PYRITES.

XL. ROCK-ALUM. The alum which is extracted from pyritous mineral matters is ſeldom very pure, on account of the vitriolic metallic ſubſtances always contained in pyrites. I have examined many of theſe alums, and by the proofs made of them, I have found that they always contained a greater or leſs quantity of martial vitriol. This alum is in commerce called rock-alum, becauſe much of it is extracted from pyritous rocks or ſtones. It appears that the names *Ice-alum* and *Rock-alum* are ſynonimous and confounded in commerce, becauſe there is no difference in the price. Frequently theſe alums, which are in great maſſes, like ſtones, (which may alſo have contributed to the name Rock-alum) have a reddiſh tinge. Theſe are the impureſt, and contain moſt martial vitriol.

A large quantity of pure alum is extracted from the neighbourhood of Puzzoli, near Naples, at a place called *Solfatara*. *See* SULPHUR.

The Abbé Nollet, who viſited this place, and examined the works eſtabliſhed there, ſays, in the Memoirs of the Academy, that the matter from which the alum is extracted, is an earth ſimilar in its conſiſtence and color to the marle found in the ſame plain. I have examined this earth, and have found that it has the appearance, and nearly the conſiſtence of white marle: but it differs eſſentially from marle in not effervеſcing with nitrous acid.

Caldrons of lead, two feet and a half in diameter, and as much in depth, are filled with this earth or ſtone to three quarters of their contents. Theſe caldrons are ſunk ſo as to be almoſt on a level with the ground under a great ſhed, at about the diſtance of four hundred paces from the ſulphur furnaces. Water is thrown into each caldron, till it riſes three or four inches above the earth. The natural heat of the ground of this place is ſufficient to heat the matter, as it makes Mr. Reaumur's Thermometer riſe thirty-ſeven degrees and a half above the freezing point: and thus fuel is ſpared. By means of this digeſtion, ſays the Abbé Nollet, the ſaline part is diſengaged from the earth, and riſes to the ſurface, whence large cryſtals are extracted.

The alum in this ſtate is mixed with much impurities. It is carried to a building at the entry into the Solfatara, and it is diſſolved with hot water in a great ſtone veſſel ſhaped like a funnel. The alum is there cryſtallized again by the heat only of the ground, and becomes purer.

XLI. PLUME-ALUM. This name is given to two very different ſubſtances. One is a matter truly ſaline, which taſtes and diſſolves in water like alum, and cryſtallizes in form of feathers. This kind of alum, which is native, is found cryſtallized in grottos where aluminous mineral waters paſs. Mr. Tournefort obſerved it in his voyage into the Levant. It is rare, and not found in commerce. The other matter to which the name of plume-alum has been very improperly given, is nothing elſe than a *friable amianthus* or *aſbeſtus.* (*b*)

XLII. **ROMAN ALUM.** In the territory of Civita Vecchia, about fourteen leagues from Rome, is found a hard ſtone whence a great deal of very fine and pure alum is extracted. The place where this ſtone is found and manufactured, is called *Aluminera della Tolſa.* This ſtone, which is neither pyritous nor calcareous, is manufactured by calcining it, as limeſtone is, for twelve or fourteen hours, after having broken it in pieces. This ſtone thus calcined is laid in ſeveral heaps upon places ſurrounded by ditches filled with water. It is ſprinkled with this water three or four times each day, for forty days, or till the calcined ſtone enters into a kind of efferveſcence, and is covered with a reddiſh efflorescence. Then the ſtones are boiled with water in caldrons so as to diſſolve all the alum which is formed, and the water is then evaporated to the point of cryſtallization. This water is made to flow quite hot into oaken veſſels, where, by cooling, a great quantity of irregular cryſtals are formed of a pale reddiſh tinge. In this ſtate the Roman alum is ſold. It is not in large maſſes like rock-alum, but in lumps of the ſize of almonds, nuts, or eggs. This alum is alſo mixed with much reddiſh duſt. I have carefully examined the purity of Roman alum, and I have found it to exceed much the purity of rock-alum. It contains no metallic or vitriolic matters; and is therefore preferred for certain dyes, the beauty of which is hurt by the ſmalleſt quantity of martial vitriol. Its price alſo is greater than that of rock-alum. (*c*)

Alum is very uſeful in ſeveral arts, and chiefly in dying, to which it is eſſentially neceſſary, as it heightens the intenſity and luſtre of moſt colors. It is even abſolutely neceſſary to give ſolidity to all thoſe colors which reſide in gummy ſubſtances. Without alum, theſe dyes would be only confuſed ſtains, which might be waſhed out by water. *See* Dying.

Alum is an aſtringent drug of powerful efficacy; conſequently it is proper for diſeaſes where the principal indications are to fortify and conſtringe, as

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(*b*) Alum is ſometimes found native with a lanuginous or plumoſe appearance, and it is then called *plume alum.* It is probably formed by the decompoſition of pyrites, or ſome compound containing ſulphur, and clay. By the diſſipation of the phlogiſton of the ſulphur, the vitriolic acid is diſengaged, and unites with the argillaceous earth, forming alum.

The name *plume-alum* is alſo frequently given to a ſtriated ſtone of the aſbeſtus kind, called alſo *falſe aſbeſtus. See* Asbestus.

Laſtly, this name is given by Baſil Valentine, and other alchemical authors, to a compound formed of arſenic united with vitriolic acid.

(*c*) A remarkable circumſtance attends the cryſtallization of alum, namely, that good cryſtals of this ſalt cannot be formed, unleſs an alkaline lixivium or urine be added to the lixivium of alum when ſet to cryſtallize. Chemiſts ſuppoſed that by adding theſe alkaline matters, ſome metallic or impure earthy ſubſtance which prevented the cryſtallization was precipitated; but Mr. Marggraaf found by experiments that he could not form good cryſtals by combining vitriolic acid with earth of alum, with calcined alum, or with clay, unleſs he added a lixivium of fixed or volatile alkali, or urine. He ſuppoſes that theſe alkaline lixiviums produce their effect either by engaging a ſuperabundant acid, or ſome greaſy matter which prevents the cryſtallization.

for immoderate menſtrual and lochial diſcharges, loſſes of blood, fluor albus, diarrheas, hæmorrhages, vomitings of blood, and even ſome kinds of hemoptoes. But it is neceſſary to obſerve on the ſubject of this remedy, and even of all other aſtringents, that they ought only to be preſcribed by intelligent phyſicians, who can diſtinguiſh whether or not theſe diſeaſes proceed from or are accompanied with inflammation, or too great plenitude : for in theſe caſes, aſtringents, ſo far from being uſeful, muſt be pernicious, and increaſe the cauſe of the evil. Alum is improper in theſe maladies, but when it is evident that they proceed from a mere relaxation, or from a rupture of the veſſels : in theſe caſes it has excellent effects.

As alum is one of the ſtrongeſt aſtringents, and as it is even ſomewhat cauſtic, ſeveral intelligent phyſicians, as Mr. Cartheuſer, and Mr. Baron, in his Notes on Lemery's Chemiſtry prohibit the internal uſe of it ; notwithſtanding which it is every day uſed ſucceſsfully in the above-mentioned caſes. However, it is prudent to adminiſter alum at firſt in very ſmall doſes only, as two or three grains except in very urgent caſes, where it may be given to ten or twelve. It may be given either alone, or joined with other aſtringent or blunting medicines, according to the particular indications.

Alum being ſuſceptible of decompoſition by all alkaline and calcareous matters, it muſt not be mixed with theſe ſubſtances, when intended to act as an aſtringent. Alum is often uſed externally ; it conſtringes and fortifies conſiderably the parts to which it is applied : conſequently it is an efficacious repellent, and is uſeful in collyriums and in aſtringent gargariſms. When calcined, its powder is ſprinkled on ſoft and fungous fleſh, which prevents the cicatriſation of ulcers. It abſorbs their moiſture, dries and conſumes them.

XLIII. ALUMINOUS. Whatever contains alum, or partakes of the nature of that ſalt is called aluminous.

XLIV. ALKANET. (*d*)

XLV. ALMONDS. (*e*)

XLVI. ALOES. (*f*)

XLVII. ALTHEA. (*g*)

(*d*) ALKANET. The cortical part of the root of this plant, which is a kind of *Bugloſs*, contains a red colorific matter, capable of being extracted by oils, by wax, and by ſpirit of wine. Wax thus colored, applied to warm marble, leaves a red ſtain.

(*e*) ALMONDS, *ſweet* and *bitter*, contain an expreſſible oil and farinaceous earth. The bitter part of bitter almonds is not expreſſed with the oil, but may be diſſolved by digeſtion in aqueous and in ſpirituous liquors, and with theſe may be diſtilled. Waters diſtilled from bitter almonds, or from moſt other bitter vegetables, fruits, and flowers, which have a ſimilar flavor to them, are poiſonous to birds, to ſome animals, and have ſometimes been ſo to men.

(*f*) ALOES is an inſpiſſated bitter juice extracted from the leaves of a plant of the ſame name. It is partly gummy, and partly reſinous ; and the gum and reſin are ſo well mixed together, that moſt of the juice is ſoluble either in aqueous or ſpirituous menſtruums.

(*g*) ALTHEA, or *Marſh-mallow*. Two ounces of the root of althea yielded, with water, ten drams and fifty grains of mucilaginous extract ; and afterwards, with ſpirit, forty-one grains of reſin. The ſame quantity of that root treated firſt with ſpirit gave ſix drams of a reſinous extract, a conſiderable part of the mucilage diſſolving in that menſtruum along with the reſin. The remainder boiled in water gave five drams and forty-eight grains of pure mucilage. The indiſſoluble earthy part was one-fourth part of the root, and one half of the leaves of althea. *Neuman.*

XLVIII. AMALGAM. This word is applied to the allays of metallic matters with mercury.

Mercury being a metallic ſubſtance cannot contract any union with earthy matters, not even with the earths of metals, when deprived of their phlogiſton, and their metallic form. But it is capable of being allayed more or leſs eaſily with almoſt all metallic ſubſtances.

As mercury is habitually fluid, as it ought to be conſidered as a metal perpetually in fuſion, and as it is ſufficient for moſt combinations that one of the two bodies that are to be combined be fluid, it follows that without the help of heat, mercury may be amalgamated with many metallic ſubſtances. There are two methods generally uſed of making amalgamas. The firſt is merely by trituration, and without heat. The ſecond is by fuſing the metal which is to be amalgamated, and by adding to it, when fuſed, the intended quantity of mercury.

Metals, by their union with mercury, become friable and capable of being pulverized, when the mercury is only in ſmall quantity. But when the mercury is added in larger quantities, the metals are by it reduced to kinds of paſte, which has no ductility nor tenacity.

Of all metals, gold has the greateſt affinity to mercury, and unites with it moſt eaſily. For this purpoſe nothing more is requiſite than that the mercury ſhould be ſlightly rubbed on a piece of gold, or that it remain ſome time in a golden veſſel. The ſurface of the gold which has touched the mercury becomes white as ſilver; and if the gold is thin, its conſiſtence is deſtroyed in that place, ſo that it very eaſily breaks. But the amalgamation of mercury with gold is conſiderably accelerated by dividing the gold into very ſmall parts or very thin plates. All metals ought to be ſo divided, when they are to be amalgamated by trituration without fuſion or heat. *(b)*

Silver may be amalgamated nearly in the ſame manner as gold. Mr. Gellert has obſerved a ſingular and remarkable phenomenon in this amalgam, which is, that its ſpecific gravity is not only greater than the intermediate ſpecific gravity of the mercury and of the ſilver, but that it is even greater than the ſpecific gravity of mercury, although ſilver be greatly lighter. *See* SILVER *and* MERCURY.

Mr. Gellert aſcertained this fact, not only by obſerving that the amalgam of ſilver ſinks to the bottom of a veſſel containing mercury, but alſo by the exacteſt hydroſtatical experiment. *See his Metallurgic Chemiſtry. Tom. I.*

The amalgams of gold and ſilver, and particularly the firſt, are much uſed for the ſeparation of theſe two metals from their ores, or rather from the earthy and ſtony matters with which they are mixed. *See* Ores *of* Gold, and of Silver. Theſe amalgams are alſo uſed for ſome kinds of *gilding* and *ſilvering*. See theſe two words. The amalgam of ſilver is alſo employed for the *Arbor Dianæ*. *See* Arbor Dianæ.

(b) As an amalgam of gold is much uſed for gilding metals, we ſhall mention that the plates or grains of that metal may be more eaſily and perfectly amalgamated by applying them heated hot to the mercury, which ought alſo to be previouſly heated till it begins to ſmoke, and by ſtirring the mixture with an iron rod till the gold diſappears, which will be very ſoon. When the quantity of mercury is ſo large that the maſs is fluid when cold, the ſuperfluous part of it may be ſeparated by paſſing it through ſoft leather: this contains a very ſmall portion of gold. The remaining amalgam has the conſiſtence of butter, and contains about one part of mercury to two parts of gold, but is nearly as white as ſilver.

The amalgamation of all metals with mercury is much facilitated by heat. But the amalgamation of thoſe metals which unite difficultly with mercury cannot be effected without heat. For this purpoſe, the mercury ought to be heated till it begins to riſe in vapors; and the metals of difficult fuſion, which we ſuppoſe to have been previouſly divided into ſmall parts, ought to be made red by fire, and quickly triturated with the hot mercury. As to the metals which melt before they become red, ſuch as tin and lead, it is ſufficient to melt them, and to throw the mercury upon them, ſtirring a little the mixture: and thus the amalgam is made in an inſtant.

It would be very imprudent to melt metals which require a great heat for their fuſion, as copper, for inſtance, and to add mercury to this melted metal, with an intention to make an amalgam; becauſe not only the greateſt part of the mercury would be diſſipated in vapors before it could be united to the metal, but alſo becauſe there would be great danger of exploſion from the mercury, which being a rarefiable and volatile body, is capable, like all ſuch bodies, of producing this effect, when they are ſuddenly expoſed to too great heat.

Mercury amalgamates difficultly with copper, more difficultly with regulus of antimony, not at all with iron (*i*), nor, as Mr. Gellert ſays, with cobalt. But with all the other metals and ſemi-metals it may be eaſily amalgamated.

The amalgam of mercury with tin is much uſed for covering one of the ſurfaces of mirrors, and thus rendering them capable of repreſenting images more ſenſibly and perfectly. *See* Tinning *of* Looking-Glasses. This amalgam is alſo uſed for the preparation of mercury-balls, intended to purify water. *See* Balls (Mercury).

Biſmuth when amalgamated with mercury has the ſingular property of ſo attenuating lead added to this amalgam, that a great part of this metal may be paſſed through leather along with the mercury. Mr. Cramer adviſes, in order to make this experiment ſucceed, to melt the lead firſt with the biſmuth, and to this mixture to add the mercury. He further ſays, that if this amalgam be digeſted ſeveral days, the biſmuth will be ſeparated, and will leave the attenuated lead united to the mercury.

Regulus of antimony can, as was ſaid above, very difficultly, be united with mercury. Mr. Gellert ſays, that to make this amalgam ſucceed, the regulus ought to be put into hot mercury, and the whole covered with water. But that when the regulus of antimony has been prepared by means of iron, or an alkaline earth, this amalgam may be made much better, ſo that the regulus ſhall not ſeparate, after ſtanding ſome time, from the mercury, as it uſually does.

(*i*) Dr. Lewis obſerves, that mercury adheres to, and coats the ends of iron peſtles uſed for the trituration of amalgams, and that a plate of tough iron may be rendered brittle by keeping it immerſed in mercury during ſome days. This experiment did not ſucceed with me. Hence he infers, that mercury is not incapable of acting upon iron.

The affinities of metallic ſubſtances with mercury are placed, according to Mr. Geoffroy, in the following order: gold, ſilver, lead, copper, zinc, regulus of antimony.

According to Mr. Gellert's table, they are, gold, ſilver, biſmuth, zinc, tin, lead, copper, regulus of antimony.

As the amalgams of mercury are true allays of metallic ſubſtances, all the general properties of allays are applicable to them. *See* ALLAY.

XLIX. AMBER. *See* BITUMEN.

L. AMBERGRISE. Is a ſubſtance of a grey color, which moſt chemiſts and naturaliſts have claſſed amongſt bitumens, rather from its properties and the principles it yields by diſtillation, than from any certain knowledge of its origin. For it does not appear that any truly foſſil ambergriſe is known, and that any is found in commerce, but what is procured from the Indian ſeas upon which it floats in the neighbourhood of the Molucca iſlands.

Mr. Cartheuſer thinks that ambergiſe ought certainly to be conſidered as a bitumen; and he is determined to this opinion from the analyſes made of it by ſeveral chemiſts, and particularly by Neuman. From which analyſes it appears, that the ſame principles were obtained from ambergriſe as from amber, that is to ſay, phlegm, a volatile acid, partly fluid and partly ſolid, oil, and a little coaly matter.

Beſides, ambergriſe is nearly as difficultly ſoluble as amber and other bitumens in different menſtruums: but it differs from amber in this, that it is much ſofter, is not ſmooth, nor is capable of taking a poliſh. Further, it is not tranſparent, and is capable of fuſion. The heat of the hands alone is ſufficient to ſoften it like wax. It alſo leaves much leſs coaly reſiduum than amber, after diſtillation. All theſe properties denote that ambergriſe is much more oily than amber.

The agreeable ſmell of ambergriſe renders it uſeful in perfumes. Muſk however is always joined with it, or ſubſtituted for it; not becauſe muſk is cheaper, for it alſo is very dear, but becauſe its ſmell is greatly ſtronger, and goes farther in the preparation of perfumes.

Ambergriſe is alſo uſeful in medicine. It has the ſame general virtues as all the odoriferous ſubſtances, from the ſpiritus rector or highly attenuated and volatile oil, which is the principle of their ſmell. It enters into the compoſition of many cordial, ſudorific, and alexiterial waters. It is alſo ſaid to be a venereal ſtimulant. But its chief virtue conſiſts in its antiſpaſmodic and ſedative qualities ſimilar to thoſe of muſk and caſtor, and in its power of relieving certain hyſterical, convulſive, and other nervous affections. It may be taken inwardly from half a grain to ten or twelve grains or more. For, as to doſes, there can be no fixed rules about remedies and diſeaſes of theſe kinds.

LI. AMMONIAC (SALT). All neutral ſalts compoſed of any acid ſaturated with volatile alkali, may be called ammoniac ſalts. But the name *Sal-ammoniac* is more eſpecially appropriated to the neutral ſalt reſulting from the union of the acid of common ſalt with volatile alkali. All the other ammoniacal ſalts are ſpecified by particular epithets, as *vitriolic ammoniacal ſalt*, *nitrous ammoniacal ſalt*, and *vegetable ammoniacal ſalt*. We ſhall ſpeak ſucceſſively of theſe ſeveral ſalts.

All ammoniacal ſalts have the general properties of neutral ſalts, compoſed of acids and alkalis. But they differ from the neutral ſalts whoſe baſes are fixed alkalis, by their more pungent taſte, which proceeds from the leſs adheſion of acids in general with volatile alkali than with fixed alkali; in the ſecond place, by their leſs fixity, all the ammoniacal ſalts being ſemi-volatile, that is, capable of ſubliming to a certain height, when expoſed to a ſtrong enough fire. This property proceeds from the volatility of their alkaline baſes. Laſtly, ammoniacal ſalts are ſuſceptible of decompoſition by many ſubſtances not capable of producing the ſame effect on neutral ſalts whoſe baſes are fixed alkali; as we ſhall ſee by a more particular examination of the properties of theſe ſalts.

The moſt generally known and uſed ammoniacal ſalt is that which contains the acid of common ſalt. This ſalt, when very pure, is very white, ſemitranſparent, capable of forming feather-like cryſtals, or of ſubliming in cloſe veſſels into a compact ſtriated maſs.

This ſalt is eaſily ſoluble in water. It deliquiates into a liquor when expoſed ſome time to a moiſt air. It is one of the ſalts which produce the moſt cold during its ſolution in water. This generation of cold is ſo much as to ſink the thermometer eighteen or twenty degrees, and even more, according to the temperature of the atmoſphere. It appears that the hotter this temperature is, the greater cold is generated, which proceeds from the greater and quicker ſolubility of this ſalt in warm than in cold water. Mr. Gellert [*Metallurgic Chemiſtry, tom.* 1.] ſays, that if any gum or reſin be boiled in water impregnated with ſal ammoniac, theſe ſubſtances will be diſſolved in it. It is not ſurprizing that gums ſhould be thus diſſolved, conſidering that water is their proper menſtruum. But as pure water does not at all attack reſins, their ſolution in Mr. Gellert's experiment muſt proceed from the ſal ammoniac.

Sal ammoniac cannot be decompoſed merely by the action of fire in cloſe veſſels; becauſe it then entirely ſublimes, as we have already obſerved. To decompoſe it therefore, we muſt employ ſome intermediate ſubſtance capable of diſengaging either its acid or its alkali.

The acids having, from their ſeveral affinities, the ſame relations to volatile alkali as they have to fixed alkali, (*See* ALKALI VOLATILE) it follows that ſal ammoniac ought to furniſh the ſame phenomena of decompoſition by the vitriolic and nitrous acids, as common ſalt does. Theſe two acids then are capable of decompoſing ſal ammoniac, by ſeparating its acid, which paſſes alone in diſtillation, and by uniting themſelves with the volatile alkali, with which the firſt forms a vitriolic ammoniacal ſalt, and the ſecond a nitrous ammoniacal ſalt.

It is proper to obſerve upon the decompoſition of ſal ammoniac by nitrous acid, 1. That the marine acid does not riſe ſingly in diſtillation, but is always accompanied with a good deal of nitrous acid, which riſes in conſequence of its volatility, and, together with the marine acid diſengaged from the ſal ammoniac, forms an *aqua regia*. 2. That in this operation great management, ſlowneſs, and precautions are neceſſary, particularly if ſmoking ſpirit of nitre be employed; becauſe the vapors which paſs are more expanſible, and leſs condenſible than the pure vapors of the nitrous or of the marine acids, which difference undoubtedly proceeds from the reaction of theſe two acids upon each other. 3. That it is very neceſſary to attend carefully to the fire towards the end of the diſtillation, and when the matter remaining in the retort begins to be dry; becauſe it is a nitrous ammoniacal ſalt, which has the property of detonating alone, and with little heat. Prudence therefore requires that the diſtillation be not puſhed to perfect dryneſs. There is ſcarcely any operation in chemiſtry ſo liable to an exploſion as this is. *See* AMMONIAC (NITROUS SAL).

Sal ammoniac is alſo capable of decompoſition by many ſubſtances, which, by uniting with its acid, ſet at liberty its volatile alkali.

Theſe ſubſtances are calcareous earths, quicklime, fixed alkalis, and metallic matters. The moſt eſſential phenomena which this ſalt exhibits, when treated by theſe different matters, are the following:

If powdered ſal ammoniac be mixed with twice its weight of any calcareous earth, of chalk for example, alſo powdered, and the mixture be diſtilled with a proper apparatus, (*See* DISTILLATION) a large quantity of volatile alkali will paſs into the receiver, in a concrete form, very white and very beautiful, lining all the inſide of the receiver; and when the operation is over, we ſhall find in the retort a maſs containing all the acid of the ſal ammoniac, engaged and retained in the calcareous earth: if conſequently this caput mortuum be lixiviated, in order to diſſolve all its ſaline part, we ſhall find that this lixivium is impregnated with much marine ſalt with earthy baſis. See for the properties of this ſalt ACID (MARINE), and SALT (MARINE) *with* EARTHY BASIS.

In this operation a true decompoſition happens of the ſal ammoniac by the intervention of the calcareous earth. Mr. Duhamel ſeems to have been the firſt who diſcovered and publiſhed this decompoſition. He has obſerved, that the volatile alkali of the ſal ammoniac, when it diſengages itſelf in this operation, carries off with it a part of the calcareous earth. We ſhall ſoon ſee that it alſo carries off part of other ſubſtances employed to diſengage it.

Mr. Beaumé, who has ſince repeated this experiment with his uſual accuracy, and in great quantities, has obſerved, that a quantity of volatile alkali may be obtained by this diſtillation equal in weight to the ſal ammoniac employed, altho' it be certain, that there is nearly as much marine acid as volatile alkali contained in ſal ammoniac. (*k*)

This ſalt treated with quicklime is ſtill more eaſily decompoſed than with uncalcined calcareous earth. To make this decompoſition, and to obtain the volatile alkali, powdered ſal ammoniac muſt be quickly mixed with twice its weight of quicklime, ſlaked by expoſure to air, and the mixture muſt be quickly put into a great ſtone-ware retort, to which a receiver muſt be immediately

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(*k*) Mr. Duhamel and other authors have attributed this great encreaſe of weight gained by volatile alkali, during its ſeparation from the marine acid in the decompoſition of ſal ammoniac, by intervention of chalk, or other mild calcareous earth, or mild fixed alkali, to part of the ſubſtance of the earth, or fixed alkali, being carried along with the volatile alkali. The ſubſtance which volatile alkali does receive from theſe intermediate matters is not, as theſe authors have ſuppoſed, earthy, or alkaline, but is the fixable air which is ſeparated from them, when they combine with the acid of the ſal ammoniac. In this operation, therefore, we have an inſtance of what our author calls *double affinity*; (*See* AFFINITY) the acid of the ſal ammoniac combining with the earthy part of the chalk, or with the ſaline part of the mild alkali, and the volatile alkali of ſal ammoniac combining at the ſame time with the fixable air of the chalk, or of the mild alkali. That this addition of fixable air to the volatile alkali is ſufficient to render its weight equal to that of the ſal ammoniac employed, appears from Mr. Cavendiſh's experiments, which ſhew, that more than half of the weight of mild volatile alkali is fixable air. *See* AIR (FIXABLE), and ALKALI (VOLATILE).

luted. *See* Distillation. The action of the quicklime upon the ſal ammoniac is ſo quick, that a good deal of volatile alkali is diſengaged as ſoon as the two matters are mixed together, which obliges the operator to take care not to expoſe himſelf to breathe the vapors. The heat muſt alſo be attended to in this diſtillation, particularly at the beginning; becauſe then it is performed almoſt without fire.

It is very remarkable that volatile alkali, obtained by intervention of quicklime, never is, nor can be, in a concrete form, by any method. It is always liquid, and is called *volatile ſpirit of ſal ammoniac.* It is evident that it is by means of the water contained in a large quantity in the ſlaked lime, and in which the volatile alkali is diſſolved, that it thus appears in a liquid ſtate; but it is certain that this ſaline matter ſo ſtrongly adheres to this water, that it cannot be ſeparated without ſome intermediate ſubſtance; and that, on the other ſide, this ſame water is ſo neceſſary to its ſeparation from the marine acid by the intervention of the lime, that Mr. Duhamel could not obtain volatile alkali by trying to decompoſe ſal ammoniac with quicklime in the ſtate it is in when newly calcined, and ſtill hot from the kiln, and conſequently perfectly dry. (*l*)

This volatile alkali, although it be diffuſed in much water, is ſtill more active and more penetrating than that which is obtained by the intervention of other ſubſtances in a dry and concrete ſtate. Mr. Beaumé has obſerved, that the volatile ſpirit of ſal ammoniac made with quicklime, when poured into a ſolution of any ſalt with earthy baſis, does not produce the ſame effects as the ſame alkali of ſal ammoniac which has been diſengaged by calcareous earths or fixed alkalis, and which may always be procured in a concrete ſtate; as this latter volatile alkali eaſily decompoſes theſe ſalts with earthy baſes, and occaſions a copious white precipitate to fall from their ſolutions, while the former does not appear to produce any effect, but only occaſions a very light whitiſh cloud. (*m*)

Theſe differences prove that a ſingular alteration is produced upon volatile alkali by quicklime; and this alteration is probably cauſed by the quicklime depriving it of part of its inflammable principle by help of which it ſeems cryſtallizable, and conſequently by a partial decompoſition of it. Another phenomenon, no leſs important, ſupports this opinion; which is, that if volatile ſpirit of ſal ammoniac be frequently diſtilled from new quicklime each time, we may eaſily perceive that there is a conſiderable quantity of it entirely decompoſed by each

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(*l*) The volatile alkali obtained by this proceſs is cauſtic or uncombined with fixable air, and is therefore, as we have obſerved under the article Volatile Alkali, always in a liquid ſtate. This liquid volatile alkali may alſo be obtained by employing cauſtic fixed alkali inſtead of the quicklime. From Mr. Duhamel's experiment mentioned in the text, by which he found that volatile alkali could not be obtained in this proceſs, unleſs water was combined with the quicklime, it appears probable, that this operation alſo is an inſtance of double affinity, and differing only from the former operation in this reſpect; that in this proceſs the volatile alkali receives water, and in the former it receives fixable air, from the calcareous earth.

(*m*) Cauſtic or uncombined volatile alkali does not precipitate calcareous earths from acids; becauſe its power of combination with acids does not ſeem to be ſtronger than that of thoſe earths. But mild volatile alkali acts upon ſalts with baſes of calcareous earth, by what our author calls double affinity; that is, its alkaline part combines with the acid of thoſe ſalts, while its fixable air combines with the calcareous earth.

diſtillation; and that, on the other ſide, if, as Mr. Duhamel did, we lixiviate quicklime in a large quantity of water, till it makes no longer cream of lime, nor has the properties of quicklime; and if the lime thus decalcined, and reduced to the ſtate of mere calcareous earth, be employed for the decompoſition of ſal ammoniac, we ſhall then obtain a concrete volatile alkali, as if a calcareous earth had been uſed, which had never been calcined. *See* QUICKLIME. (*n*)

When ſal ammoniac is decompoſed by the intervention of quicklime, in the retort is found a ſaline earthy matter; that is, a part of the quicklime above what was neceſſary for the decompoſition, and another part ſaturated with the acid of ſal ammoniac, and forming a ſort of ſea-ſalt with earthy baſis, which ſeems to be ſimilar to that ſalt formed by uniting marine acid with an uncalcined calcareous earth, but which ought to differ from it in many reſpects, and particularly by a ſtronger adheſion of the acid to the quicklime. (*o*) This ſalt, when dry, is called improperly *fixed ſal ammoniac*, and when deliquiated into a liquor, it is called *oil of lime*, or *liquid ſhell*.

Fixed alkali, either vegetable or mineral, eaſily decompoſes ſal ammoniac, and ſeparates from it by diſtillation the volatile alkali in a concrete ſtate, if there be little or no water in theſe matters: but if theſe matters contain water, or if water be deſignedly added, the alkali, which is more volatile than the water, paſſes firſt, partly in a concrete ſtate, then the water which riſes diſſolves it wholly or partly, according to the quantity of water, and it is thus reduced to a liquid ſtate. Mr. Duhamel obſerves, that in this diſtillation alſo the volatile alkali carries off with it a portion of the fixed alkali which is employed to diſengage it. (*p*)

The ſalt remaining in the retort after this diſtillation is common ſalt, entirely ſimilar to ordinary ſea-ſalt, if the fixed alkali employed was the mineral alkali; and ſimilar to regenerated ſea-ſalt, or ſalt of Sylvius, if the vegetable fixed alkali was employed. *See* SALT (COMMON).

Moſt metallic ſubſtances alſo act upon ſal ammoniac, and are capable of decompoſing it.

Silver, copper, iron, tin, lead, and mercury, well mixed with this ſalt, and diſtilled together, diſengage its volatile alkali. The ſemimetals alſo produce the ſame effect. After the diſtillation is finiſhed, the metal is found combined with the acid of ſal ammoniac. This ſilver becomes *luna cornea*, and lead becomes *plumbum corneum*. In this manner Mr. Margraaf prepared his *plumbum corneum* which he employed in his operation for phoſphorus. *See* PLUMBUM CORNEUM; and PHOSPHORUS.

A remarkable thing occurs in this decompoſition of ſal ammoniac by lead, for which Mr. Margraaf requires a calx of lead, ſuch as minium, rather than lead

itſelf

(*n*) Mr. Duhamel evidently reduced his quicklime to mild calcareous earth, that is, combined it with fixable air; we need not, therefore, wonder that the volatile alkali which he obtained was alſo mild, or combined with that air.

(*o*) The ſalt formed by decompoſing ſal ammoniac with quicklime is preciſely the ſame as the ſalt formed by uniting marine acid with uncalcined calcareous earth: for the acid, uniting with uncalcined calcareous earth, deprives it of its fixable air, and reduces it to the ſame ſtate as the calcined earth, or quicklime is in.

(*p*) See the note (*i*).

itſelf, for the conveniency of the mixture; which is, that the volatile alkali which paſſes over in the diſtillation, altho' very ſtrong and much dephlegmated, is always in a liquid or fluor ſtate, which ſhews, that upon this occaſion, as in many others, metallic calces produce the ſame effect as quicklime.

As to mercury, it very certainly decompoſes ſal ammoniac, and ſeparates its volatile alkali. But if more ſal ammoniac was added than the mercury can decompoſe, this undecompoſed part of the ſalt remains united with the combination of marine acid with mercury, and cannot by cryſtallization or ſublimation be ſeparated from thence. This fact has been aſcertained by Mr. Macquer; of which a detail is given in his Memoir upon the *Count de la Garaye's Tincture of Mercury*, printed in the collection of the Academy of Sciences in the year 1755.

Junker ſays, that regulus of antimony treated with ſal ammoniac diſengages the volatile alkali, and is converted into butter of antimony.

It is proper to obſerve on this occaſion, of the decompoſition of ſal ammoniac by earthy and metallic ſubſtances, which unite with its acid and diſengage its volatile alkali, that as the volatile alkali thus diſengaged is capable of ſeparating in its turn all theſe ſame ſubſtances united to an acid, and even to the marine acid, there ſeems to be ſomething contradictory in the affinities of volatile alkali, and of earthy and metallic ſubſtances. Mr. Baron, in his Memoir upon Borax, and Mr. Macquer, in his Elements of Practical Chemiſtry, explain theſe effects in a plauſible manner, by the great difference of the fixity and volatility of theſe ſubſtances. It appears nevertheleſs that the ſubject is ſtill ſomewhat obſcure, and requires a more particular examination.

If, inſtead of mixing with ſal ammoniac ſufficient quantities of copper, iron, and even of moſt other metals, and with proper circumſtances for the decompoſition, theſe metals were employed in a ſmaller quantity, and that the heat was immediately raiſed ſufficiently intenſe for ſublimation, the ſal ammoniac would then be obtained ſublimed, or flowers of undecompoſed ſal ammoniac would be raiſed, containing ſome part of the metals. By this method chemical preparations or medicines are made, which are named from the metals employed. Thus flowers of ſal ammoniac impregnated with copper are called *ens veneris*; thoſe impregnated with iron, are called *martial flowers of ſal ammoniac*, or *martial flowers*, or *ens martis*. See *theſe words*.

There are alſo other properties of ſal ammoniac which ought to be mentioned here.

This is one of thoſe ſalts which are ſoluble in ſpirit of wine. Mr. Macquer, in the above quoted memoir, has determined that thirty-two parts of well rectified ſpirit of wine are neceſſary for the ſolution of one part of ſal ammoniac.

Sal ammoniac acts conſiderably on mercury ſublimate corroſive. It diſſolves this ſalt and unites with it, and occaſions no decompoſition to either of the ſalts. From the union of theſe two ſalts, a mixed ſalt is produced which chemiſts have called *Salt Alembroth*. See this word.

Sal ammoniac is employed advantageouſly in many arts. It is particularly uſeful in the tinning of copper and iron. *See* TINNING. It is alſo employed in the fuſion of gold; becauſe it has been obſerved to exalt and heighten the color of that metal.

If ſal ammoniac be treated with nitre in a crucible, and with a red heat, the nitre is obſerved to deflagrate to a certain point. This phenomenon proceeds from the inflammable matter which enters into the compoſition of the volatile alkali, which is the baſis of the ſal ammoniac. It is alſo this ſame inflammable principle which produces the good effects of ſal ammoniac in the tinning of metals.

Sal ammoniac is found ready formed in volcanos, or in their neighbourhood. It is called *native ſal ammoniac*; but it is in too ſmall quantity to furniſh the demands of artiſts. The ſal ammoniac ſold in commerce is made in great manufactories for this purpoſe.

The method of manufacturing ſal ammoniac was long unknown. Mr. Le Maire and Mr. Granger were the firſt who explained the proceſs, in very circumſtantial memoirs upon this ſubject communicated to the Academy of Sciences. An extract of theſe memoirs may be found in Mr. Macquer's Elements of Practical Chemiſtry; for which reaſon, we will only briefly mention, that in Egypt, where moſt of the ſal ammoniac is made which is in commerce, ſoot is employed for this purpoſe, which is produced by burning the dung of cows and camels, which are the ordinary fuels of that country. This ſoot is put into large glaſs veſſels arranged near each other in oblong furnaces. The fire is raiſed gradually, that all the volatile principles of the ſoot may be driven off; then the fire is encreaſed towards the end, by which the ſal ammoniac is ſublimed, the materials of which were contained in the ſoot; the glaſs veſſels are then broken to get out the loaves of ſal ammoniac, which are formed upon the upper interior parts of the glaſs veſſels. Theſe loaves or cakes, as they are found at the ſhops of druggiſts, weigh from three to five or ſix pounds. They are more or leſs blackened by a quantity of fuliginous or ſooty matter, which riſes with the ſal ammoniac in the ſublimation. *See* SOOT.

Sal ammoniac may be purified from this extraneous matter by the means commonly employed for the purification of ſalts, that is, by diſſolving in water, filtrating, cryſtallizing, and by ſubliming a ſecond time, if this ſhould be thought neceſſary: a ſal ammoniac is then obtained perfectly white and pure. Sal ammoniac may be made by combining marine acid to the point of ſaturation with volatile alkali, obtained from the diſtillation of animal or vegetable ſubſtances, and by filtrating, cryſtallizing, and ſubliming the ſaline matters thus combined. But this ſal ammoniac would coſt more than the price it is generally ſold for. Although the volatile alkali uſed for this proceſs, ſolid or liquid, be very impure and impregnated with much empyreumatic oil, from which it is difficult to purify it, yet the ſal ammoniac obtained from it by this method is very pure and good; becauſe the volatile alkali, when it combines with an acid, ſeparates itſelf from all the ſuperabundant oil with which it was at firſt combined: hence the volatile alkali obtained by decompoſing ſal ammoniac is better diſengaged from all ſuperabundant oily matter than what is obtained by any other method. But we muſt obſerve, that the volatile alkali obtained from ſal ammoniac always carries off with it ſome of the ſubſtance employed for the decompoſition. This circumſtance muſt produce different effects in chemical experiments, to which attention ought to be given. (q)

(q) To the above article we ſhall add; 1. Sal ammoniac requires four times its quantity of water to diſſolve in that liquid. 2. Its volatility is diminiſhed ſo much by repeated ſublimations, that it remains half fluid at the bottom of the ſubliming veſſel; and when ſal ammoniac was repeatedly ſublimed together with mercury corroſive ſubli-

LII. AMMONIACAL SALT (VITRIOLIC). This is a neutral ſalt compoſed of vitriolic acid ſaturated by volatile alkali.

This ſalt may be made by ſeveral different methods.

1. By combining vitriolic acid with diſengaged volatile alkali.

2. By decompoſing ſal ammoniac by vitriolic acid in Glauber's manner. If this latter method be uſed, a marine acid is obtained by diſtillation, ſtrong in proportion to the concentration of the vitriolic acid employed; and in the retort the vitriolic ammoniacal ſalt remains, which *Glauber* called his *ſecret ſal ammoniac.*

3. By decompoſing all vitriolic ſalts with earthy or metallic baſes, by means of volatile alkali. *See* ALKALI (VOLATILE).

This ſalt has the properties of ſal ammoniac, with the differences depending on their different acids. It is ſemi-volatile; it may be entirely ſublimed; it cannot be decompoſed in cloſe veſſels without ſome intermediate ſubſtance; it has a ſharp taſte; it eaſily diſſolves in water; and is ſuſceptible of cryſtallization. This ammoniacal ſalt is not uſed in arts or in medicine. Glauber attributes many wonderful properties to it, which it certainly does not, ſo eminently at leaſt, poſſeſs.

LIII. AMMONIAC SALT (NITROUS). This ſalt is compoſed of nitrous acid ſaturated with volatile alkali. It is found in earths, or plaiſters where nitrous acid is generated, when theſe earths have imbibed a ſufficient quantity of putrid animal or vegetable ſubſtances to furniſh volatile alkali to the generating nitrous acid.

Nitrous ammoniacal ſalt may be made, as the vitriolic, by three methods:

1. By combining to the point of ſaturation nitrous acid with volatile alkali.

2. By decompoſing ſal ammoniac by means of nitrous acid.

3. By decompoſing nitrous ſalts with earthy or metallic baſes, by means of volatile alkali. *See* ALKALI (VOLATILE).

Nitrous ammoniacal ſalt has a very pungent taſte; is ſoluble in water; capable of forming beautiful needle-like cryſtals, like thoſe of ordinary nitre.

This ſalt has the ſingular property of detonating alone, when expoſed to a certain degree of heat, and without the neceſſity of addition, as in ordinary nitre, of inflammable matter. It ſeems even to inflame with leſs heat than nitre mixed with inflammable matter does.

This property proceeds from the phlogiſton or inflammable matter which enters as a principle into the compoſition of the volatile alkaline baſis of this ſalt. This property alſo furniſhes a deciſive proof of the exiſtence of this inflammable matter in volatile alkali.

This inflammability of nitrous ammoniacal ſalt renders it incapable of ſublimation, like the other ammoniacal ſalts, as an exploſion would certainly happen

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mate, and the reſiduum of each preceding operation mixed with the ſublimed ſalt, the whole matter became quite fixed in the fire, and would no longer riſe from the bottom of the glaſs. *Neuman.* 3. The degree of heat neceſſary to volatilize ſal ammoniac is a little below that of ignition, nearly the ſame with which lead is melted. 4. Pott ſays, that a ſmall quantity of ſal ammoniac may be produced by diſtilling ſea-ſalt with charcoal or with alum, or by diſtilling marine acid with Armenian bole. 5. The ſame author affirms, that the inflammability of ſulphur is deſtroyed by ſubliming it with twice its quantity of ſal ammoniac.

in the operation. Chemiſts do not ſeem to have examined particularly the properties of this ſalt; neither is it uſed in arts or in medicine, If this curious ſalt were to be more particularly examined, the operator would need the greateſt circumſpection to avoid exploſions.

LIV. AMMONIACAL SALT (VEGETABLE). This name is given to all neutral ſalts formed by combinations of volatile alkali with vegetable acids. But theſe ſalts are hitherto little known, although they deſerve to be examined. That ſaline combination formed by volatile alkali and vinegar is called *Spirit of Mindererus.*

LV. AMMONIACAL SALT (ANIMAL). As the fat of animals contains much acid, (*See* FAT) an ammoniacal ſalt might be formed by combining this acid with volatile alkali, which might be properly called animal ammoniacal ſalt. But this combination has not yet been made, or examined.

Laſtly, the phoſphoric ſalt, or native ſalt of urine, belongs to the claſs of ammoniacal ſalts; and as its acid appears to be peculiarly animal, it would alſo be in this ſenſe a true animal ammoniacal ſalt. *See* SALT (FUSIBLE) *of* URINE.

LVI. AMMMONIAC (FIXED). *(r)*

LVII. AMMONIAC (GUM). *(s)*

LVIII. AMETHYST. *(t)*

LIX. AMIANTHUS.) *(u)*

LX. ANALYSIS. Chemiſts underſtand by the word analyſis, the decompoſition of a body, or the ſeparation of the principles and conſtituent parts of a compound ſubſtance.

Chemiſtry furniſhes ſeveral means for the decompoſition of bodies.. Theſe means are all founded on the differences of the properties belonging to the different principles of which the body to be analyſed is compoſed. Thus, for example. if a body be compoſed of ſeveral principles, ſome of which have a great, and others a moderate degree of volatility, and, laſtly, others are fixed, its moſt volatile parts may be firſt ſeparated, by a graduated heat, in diſtilling veſſels, and then the parts which are next in volatility will paſs over in diſtillation; and laſtly, thoſe parts which are fixed, and capable of reſiſting the action of fire, will remain at the bottom of the veſſel. As this analyſis cannot be made but by means of fire, it is called the *Analyſis by fire.*

(r) FIXED AMMONIAC is a name given to the reſiduum formed by decompoſing ſal ammoniac with a calcareous earth. It is a ſalt compoſed of that earth and marine acid. *See* SALT (MARINE) *with* BASIS *of* CALCAREOUS EARTH.

(s) GUM AMMONIAC is a gum reſin, from an ounce of which ſix drams may be diſſolved by ſpirit of wine, or ſix drams two ſcruples and a half may be diſſolved by water. *Neuman.*

(t) AMETHYST. This is a violet-colored, frequently yellowiſh or reddiſh, pellucid gem, the ſeventh in degree of hardneſs from diamonds, fuſible by fire, which alſo deſtroys its color. It is found amongſt quartz, and is probably only a colored quartz cryſtal. This ſtone may be imitated by adding to a fritt of cryſtal-glaſs eight parts of magneſia and one part of zaffre.

(u) AMIANTHUS is the lighteſt and ſofteſt of all ſtones. It conſiſts of fibres parallel or interwove, ſo flexible, that cloth has been formed of them. By a ſtrong heat it is whitened, hardened ſo as to be capable of ſtriking fire with ſteel, and rendered brittle. It has generally been conſidered as unfuſible by fire; but Mr. D'Arcet, in a Memoir of the French Academy for the year 1766, affirms, that by a violent and long continued fire it is fuſible, and that it forms a black glaſs. This ſtone is inſoluble by acids.

It is proper to obſerve, that this method of analyſing does not ſucceed equally well upon all bodies, and that it is very imperfect upon ſome bodies, which being compoſed of principles of very different degrees of volatility, might ſeem well adapted to it. This particularly happens when the principles of ſubſtances analyſed by this method have a great adheſion with each other; becauſe in this caſe a volatile principle drags along with it a portion of the fixed principle, which would never have been raiſed by the degree of heat employed without this adheſion, and as it were, participation of the volatility of the former to the latter. Frequently, therefore, the principles obtained by this method of analyſis are in part ſtill united with each other, and are far from the proper degree of purity. In this caſe it is neceſſary to have recourſe to new diſtillations, rectifications, and purifications, to obtain them ſufficiently pure and ſeparated from each other. This inconvenience particularly attends the analyſes by fire of moſt animal and vegetable ſubſtances, in which analyſes very volatile acids and alkalis are often procured, ſtill united with much ſuperfluous heavy oil. The beſt method of avoiding this inconvenience, or at leaſt of diminiſhing it as much as poſſible, is to manage very carefully the fire; for it is evident that a too ſtrong fire would readily confound all the principles of the ſubſtance to be analyſed.

A ſecond no leſs important remark concerning the analyſis by fire, is, that by this method the *proximate principles* of very compound bodies, ſuch as moſt vegetables, cannot be obtained; becauſe theſe proximate principles being themſelves very compound, and of a delicate mixture, cannot, for the moſt part, ſupport the action of fire without a total or partial decompoſition; or, at leaſt, without receiving ſuch conſiderable alterations that they can no longer be known. This inconvenience chiefly attends thoſe proximate principles which are not poſſeſſed of great volatility, as we may ſee from the example of mild and fat oils, of gummy, reſinous, ſaponaceous, and extractive parts of vegetables. Theſe principles cannot ever be procured by diſtillation ſuch as they were in the plant.

Theſe inconveniences have induced chemiſts, particularly the modern, to ſearch for other methods of decompoſing bodies, and ſepararing their principles.

They have found one method which wonderfully ſupplies in many caſes the defects of the analyſis by fire.

This ſecond method of decompoſing bodies is founded on the different degrees of ſolubility in moſt menſtruums, which the different principles poſſeſs. Thus when a body is compounded of ſeveral ſubſtances; one of which, for inſtance, is ſoluble only by ſpirit of wine, a ſecond is ſoluble only by water, and a third is ſoluble only by ether; theſe ſubſtances may be very eaſily ſeparated from each other, by ſubmitting ſucceſſively the compound body to the action of theſe menſtruums, each of which diſſolves that particular ſubſtance to which it has an affinity, and from which it may be afterwards eaſily ſeparated. This method of analyſis is excellent to ſeparate without any ſenſible alteration the greateſt part of the proximate principles of vegetables, and to obtain them as they exiſt in the plants. If, for inſtance, a vegetable matter contain gum, reſin, and an oil or oily concretion not ſoluble in ſpirit of wine; we may firſt deprive it by water of its mucilaginous and gummy parts, which may afterwards be obtained in their natural ſtate merely by evaporation of the water; then, by applying to this vegetable matter ſpirit of wine, we may extract its reſinous parts; and laſtly, we may, by treating it with ether, ſeparate its oily part, which could not be diſſolved the water or the ſpirit of wine. It is afterwards eaſy to obtain the ſubſtances diſſolved by the ether and ſpirit of wine, pure and free from their menſtruums, either by evaporation, or by addition of much water, which ſeparates the oily and reſinous parts. *See* Spirit *of* Wine, and Ether.

As this method of ſeparating the principles of bodies is ſolely founded on the action of menſtruums, this kind of analyſis has been called Analysis *by* Menstruums.

What has been ſaid on this ſubject is ſufficient to make its great utility appear. We may add, that in ſome caſes this is the only analyſis which can be applied, and by which a perfect and compleat ſeparation can be effected. If, for example, the body to be analyſed conſiſts of two ſubſtances which equally reſiſt the action of fire, as gold and ſilver, it is evident that theſe two ſubſtances cannot be ſeparated from each other but by means of a menſtruum which can only diſſolve one of them. Thus, by expoſing a maſs compoſed of gold and ſilver to aqua regia, which diſſolves the gold only, or to nitrous acid, which diſſolves only the ſilver, the ſeparation of theſe two metals may be effected. The operation called *Parting* ought then to be conſidered as the true analyſis by menſtruums. *See* Parting.

We may ſay the ſame of all decompoſitions and precipitations which are made in numberleſs chemical operations by intermediate ſubſtances, either by the humid method, or by the dry, in different fuſions. In all theſe caſes, the intermediate ſubſtance employed effects the precipitation or ſeparation of the body intended to be ſeparated, by really diſſolving another body to which the former was united. Thus the analyſis by menſtruums is at leaſt of as extenſive utility as the analyſis by fire, ſince it takes place in almoſt all the operations of chemiſtry.

It is true, that in many caſes the analyſis by menſtruums, as well as that by fire, is incomplete. This inconvenience happens when there is in the compound body to be analyſed ſome intermediate ſubſtance, by means of which the menſtruum is rendered capable of acting upon ſome of the principles, which it ought not to do, in order to have a complete and perfect ſeparation. But theſe inconveniences may be prevented or repaired.

Frequently it is neceſſary, in order to make a perfect analyſis of bodies, to unite theſe two methods by fire and by menſtruums: the one may be made to aſſiſt the other; and from theſe combined means a decompoſition reſults much more perfect, and more accurate, than could have been obtained by either of them ſeparately. If, for inſtance, we intended to ſeparate from ſpirit of wine ſuperabundant quantities of oil and water which are generally united with it, we ought, inſtead of diſtilling it alone, to mix with it ſome fixed akali, or very dry earthy matter, and then to proceed to the diſtillation: theſe alkaline or earthy ſubſtances acting upon the oil and water will retain and fix them; by which means the ſpirit of wine is allowed to riſe much purer in diſtillation.

We ſhall ſay nothing more here upon analyſis in general. This ſubject is ſo extenſive, that to make particular applications of it, we ſhould be obliged to conſider all the objects in chemiſtry. Thoſe who know the uſe of general principles will eaſily apply theſe to particular operations; and longer details would be fatiguing and uſeleſs to others. It is nevertheleſs proper to mention the general articles which are related to this. *See* DECOMPOSITION, DISTILLATION, SUBLIMATION, PRECIPITATION, EXTRACTION, SOLUTION.

LXI. ANGELICA. *(w)*

LXII. ANIMAL. *(x)*

LXIII. ANIME. *(y)*

LXIV. ANISE. *(z)*

LXV. ANNOTTO. *(a)*

LXVI. ANTIMONY. Antimony is a mineral of a metallic, ſhining, leaden color, the maſſes of which have no determinate figure, but are compoſed of long, brittle, parallel needles. It is compoſed of a ſemimetallic ſubſtance called its *regulus*, united with ſulphur, as moſt metallic ſubſtances are in their mineral ſtate.

There are two kinds of antimony, namely, that which is called *native* or *mineral*, and is in the ſame ſtate as when it is dug out of the earth; and *fuſed antimony*, ſo named, becauſe it has been actually fuſed in order to ſeparate it from adhering ſtones and earths. This operation, which ought rather to be called liquation than fuſion, conſidering theſe words in their metallurgic ſenſe, is made in great perfection upon the grounds whence antimony is dug. The proceſs is very ſimple and eaſy. It conſiſts in placing the mineral in earthen pots, pierced in their bottoms with ſmall holes. Theſe pots are placed in a furnace, where they receive the neceſſary heat for the fuſion of the antimony. As it is very fuſible, (for it melts before it is red) this degree of heat is much leſs than is neceſſary for the fuſion of the earthy and ſtony matters mixed with it. The antimony thus melted runs through the holes at the bottom of the pots, and is received in other pots placed below, and defended from the heat as much as is poſſible. The antimony is allowed to cool and fix in theſe receivers, from which it therefore takes its form of cakes, in which it is ſold. The countries which furniſh moſt antimony are Hungary and Auvergne, whence the names *Hungarian antimony*, and *Auvergne antimony*. Antimony is alſo found in other countries, and in different forms; upon which ſubject conſult the article ORE *of* ANTIMONY.

(w) ANGELICA. The root of this plant contains an eſſential oil, and a reſinous matter. *Neuman.*

(x) ANIMAL KINGDOM. *See* KINGDOM.

(y) ANIME, according to Neuman, is a reſin totally ſoluble in ſpirit of wine. It is called improperly *gum anime*. Other authors mention two ſubſtances to which this name is given, one of which is brought from India, and is reſinous: the other is brought from Braſil, and is ſimilar in appearance and inſolubility in ſpirit of wine, or in water, to the ſubſtance called *gum copal*. All the anime which is to be found in ſhops of druggiſts is of this latter kind; and if it does not proceed from the ſame tree as gum copal, is ſcarcely diſtinguiſhable from it.

(z) ANISE. The outer thin ſkin of the ſeeds of this plant contains an eſſential oil, and the kernel itſelf contains an inodorous, inſipid, expreſſible oil. *Neuman.*

(a) ANNOTTO is a red maſs extracted by infuſion in water, and fermentation from the pellicles of the ſeeds of an American tree. To water this maſs gives only a pale browniſh-yellow color, and is very little ſoluble in that liquid.* It readily diſſolves in ſpirit of wine, and gives a bright orange color: hence it is uſeful as an ingredient in varniſhes and lacquers. By alkaline ſalts it is rendered ſoluble in water, without any change produced upon its color. Wool and ſilk boiled in this ſolution acquire a deep, but not durable orange dye. Its color is not changed by alum or by acids; but is diſcharged by ſoaps, and is deſtroyed by expoſure to air. It is ſaid to be an antidote to the poiſonous juice of manioc, or caſſava.

As many remedies of great conſequence are prepared from antimony, and as alchemiſts have ſuppoſed it eſſential to the *great work*, a very great number of chemical operations have been made upon this mineral, the reſults of which are diſtinguiſhed by particular names. We ſhall here give a ſummary account of theſe operations, and ſhall make references for the particular details and explanations.

The metallic part of antimony is diſengaged from its ſulphur by ſeveral methods. The firſt and ſimpleſt is torrefaction, commonly called *Calcination of Antimony*. It conſiſts in expoſing crude antimony, groſly powdered, in a flat and ſhallow earthen veſſel, to the action of a moderate fire, taking care to ſtir it conſtantly. During this calcination, the ſulphur, being leſs fixed than the metalline part, is gradually evaporated. The calcination is continued till no more ſulphureous vapors riſe. What remains after the calcination is the metallic part of the antimony ſeparated from the mineral ſulphur, and even deprived of part of its own inflammable principle. This ſubſtance is much more fixed and leſs fuſible than antimony, becauſe in general metallic earths are ſo much more fixed and leſs fuſible as they are deprived of more of their inflammable principle. It is called *Calx of Antimony*. It is of a grey aſh color. When taken internally it is violently emetic and purgative, which antimony is not, becauſe its metallic earth is inveloped by ſulphur, and thereby deprived of moſt of its properties.

Calx of antimony, expoſed to a great heat in a crucible, melts, and appears when cold a hard, compact, brittle, ſhining maſs. This melted matter is ſometimes tranſparent, and of a more or leſs deep hyacinthine color. It is then called *Glaſs of Antimony*, becauſe it has the appearance and properties of a vitrified ſubſtance.

Sometimes calx of antimony, when fuſed and cooled, becomes an opake brown maſs. It is then called *Liver of Antimony*.

Theſe differences proceed from the greater or leſs quantity of inflammable principle which remains united with the metallic earth of the antimony. They conſequently depend on the length and accuracy of the calcination.

When this calcination has been ſlight, and much inflammable matter remains united with the earth of antimony, then the calx produced is capable of melting with leſs heat, and the reſult is liver of antimony, which ought to be conſidered as an intermediate matter betwixt the vitrified and metallic ſtates.

If the calcination has been more compleat, the calx is of more difficult fuſion, and the reſult from it is a vitrified ſubſtance.

Laſtly, if the calcination has been as perfect as is poſſible, the remaining calx is ſtill more refractory, and is even incapable of fuſion and vitrification.

The calx, the liver, and the glaſs of antimony, are violently emetic. The phenomena which they ſhew when treated with chemical agents, are ſo much more ſimilar to thoſe exhibited by the regulus of antimony, as they approach more to the reguline ſtate, that is to ſay, as they are more perfectly deprived of mineral ſulphur, and leſs deprived of their inflammable principle.

Theſe three preparations of antimony being treated in cloſe veſſels, and fuſed with matters capable of furniſhing phlogiſton, ſuch as the black flux, are reduced not into antimony as they were originally, but into a ſemi-metallic, hard, brittle ſubſtance, of a dull white color, and compoſed of ſhining facets. This ſubſtance is called *Regulus of Antimony*. The cauſe of this change is, that by calcination this mineral is deprived of all the ſulphur which is found united with its ſemi-metallic or reguline ſubſtance, and that this ſulphur is not reſtored to it in the reduction above-mentioned. If then it be intended to reſtore the properties of antimony to its calx, liver, glaſs, or regulus, it ought to be combined by fuſion not only with phlogiſton, but alſo with a proper quantity of mineral ſulphur.

Antimony may be diſengaged from its ſulphur, and at the ſame time reduced either into regulus, liver, or white calx entirely deprived of its phlogiſton, by ſeveral other proceſſes, much ſhorter and more expeditious than calcination, which is always very long.

If a mixture of four parts of crude antimony pulveriſed, three parts of tartar, and one part and a half of nitre, be projected at different times into a large red-hot crucible, and ſurrounded with burning coals; and when the detonation is finiſhed, the fire raiſed ſo as the matter ſhall be fuſed; then upon breaking the crucible when cool, a maſs is found conſiſting of two diſtinct ſubſtances, and which may be ſeparated from each other by the ſtroke of a hammer. The lower ſubſtance is the reguline metallic part, and is called *Regulus of Antimony*. The ſubſtance lying above this is called *Scoria of the Regulus of Antimony*. This ſcoria is alkaline and acrid: it attracts the moiſture of the air, and is compoſed, 1. Of the alkalis of the nitre and of the tartar alkaliſed by each other in the operation; 2. Of a portion of the ſulphur of the antimony, which during the operation united with the alkali and formed a liver of ſulphur; 3. A portion of reguline ſubſtance of antimony diſſolved by this liver of ſulphur; 4. Laſtly, ſome vitriolated tartar which was formed by a part of the acid of the ſulphur combining during the detonation with the fixed alkali.

From the ſolution of the ſcoria of the regulus of antimony in water, a yellow reddiſh matter is depoſited in a certain time, which is nothing elſe than a part of the ſulphur and of the regulus of antimony which quit the alkali without ſeparating from each other; conſequently it is a kind of *Kermes*. When the ſolution of this ſcoria is ſaturated with any acid, a pretty large quantity of reddiſh matter is precipitated, which is compoſed, like the former, of ſulphur and reguline parts. This matter is called SULPHUR (GOLDEN) *of* ANTIMONY, *which ſee*.

Theſe two precipitates, and particularly the latter, are very emetic, although in them the reguline part is, as in antimony, which has no emetic quality, united with a large portion of ſulphur. The true reaſon of this difference is, that in crude antimony the ſulphur is much more intimately and ſtrongly united to the ſemi-metallic part than it is in the golden ſulphur.

Moſt metals, as iron, copper, tin, lead, and ſilver, have a greater affinity to ſulphur than the regulus of antimony has. Hence this regulus may be precipitated in fuſion, and its ſulphur may be ſeparated by means of theſe metals. The regulus thus obtained is called the *Regulus of the Metals*. The name of the particular metal employed to make this precipitation is added. Thus it is called, the *Regulus of Tin*, the *Regulus of Copper*, the *Martial Regulus*, according to the metal uſed in the operation. Iron is moſt frequently employed to make this regulus, becauſe of all metals it has the greateſt affinity to ſulphur, and for that reaſon ſeparates moſt eaſily and perfectly the reguline part. *See* Regulus *of* Antimony (Martial).

If inſtead of detonating antimony with a ſufficient proportion of nitre to obtain the regulus, equal parts of theſe two ſubſtances are employed; then, after the detonation, no regulus will be found at the bottom of the crucible, but a brown, opake, brittle maſs, of no metallic appearance; in a word, ſimilar to that maſs which is obtained by melting the calx of antimony alone, when too little dephlogiſticated to be capable of vitrification. This maſs is, properly ſpeaking, the ſubſtance called *Liver of Antimony*, from its color, which ſomewhat reſembles that of the liver of animals. By this proceſs the liver is always made in ſmall chemical laboratories. But it is ſaid that in Holland, where many chemical operations are objects of manufacture, the liver of antimony is made by melting the calx of this mineral alone, ſufficiently dephlogiſticated. The liver of antimony prepared by either of theſe methods is a violent emetic and purgative. Several diſpenſatories require it to be employed in the preparation of *emetic tartar*. *See this word*. It is alſo uſed to purge horſes.

When in this operation of liver of antimony by nitre, the matter has been well fuſed, it is obſervable that the maſs found upon breaking the crucible is compoſed of two diſtinct ſubſtances. The liver of antimony, being the heavier of the two, is at the bottom; and above it lies a lighter and more ſaline matter, called the *ſcoria*, which may be ſeparated by a hammer. This ſcoria is nearly of the ſame nature as that of the ordinary regulus. It is very acrid and alkaline, and contains vitriolated tartar, and liver of ſulphur, by which ſome liver of antimony is kept diſſolved. A golden ſulphur of antimony may be alſo precipitated from this ſcoria by any acid.

When in the operation of the liver of antimony, the fuſion has not been ſufficient, or the mixture has been cooled too ſuddenly, then the ſcoria remains mixed with the liver of antimony, which it in ſome meaſure keeps diſſolved.

Laſtly, in detonating antimony with thrice its weight of nitre, after the operation, a maſs perfectly white and void of color is found. This maſs is a mixture of calx of antimony with certain ſaline matters. Theſe are, 1. Nitre alkaliſed by the phlogiſton of the ſulphur, and of the regulus of antimony; 2. Vitriolated tartar, proceeding from a portion of the acid of the ſulphur, combined with the alkali of the nitre; 3. A portion of nitre undecompoſed.

As to the calx of antimony obtained by this operation, it is perfectly white, becauſe entirely deprived by nitre not only of all the mineral ſulphur, but alſo of its own phlogiſton.

This calx well waſhed, ſo as to be cleanſed from the ſalts, is called *Diaphoretic Mineral*, *Diaphoretic Antimony*, and *White Calx of Antimony*. It is neither emetic nor purgative; for which reaſon a diaphoretic quality has been attributed to it.

The white calx of antimony is not ſoluble in acids. It is exceedingly fixed, and often refractory, being capable of ſuſtaining the greateſt violence of fire without vitrifying or melting. All theſe properties, ſo different from thoſe of the regulus, the liver, and the glaſs of antimony, proceed from its being entirely diveſted of phlogiſton by nitre.

The quantity of nitre employed in this operation is more than ſufficient to dephlogiſticate entirely all the earth of the antimony, ſince in the ſcoria is found ſome nitre undecompoſed, becauſe there was not phlogiſton enough in the antimony for that purpoſe.

Theſe phenomena of the calcination of antimony, which are conformable to thoſe of all other metallic calcinations, prove in a ſatisfactory manner, that metallic matters owe their volatility, their fuſibility, and their ſolubility in acids to their phlogiſton.

The maſs remaining in the crucible after the detonation, in the operation of diaphoretic antimony, and which conſequently contains the calx of antimony and the ſalts reſulting from the operation, receives aperitive, and even purgative qualities from the ſalts contained in it. It is called *Unwaſhed Diaphoretic*. It forms alſo the ſubſtance called the *Flux of Rotrou*.

When the reſult from the detonation of diaphoretic antimony is waſhed, in order to cleanſe it from the ſalts, the water diſſolves not only the ſaline matters, but alſo the fineſt part of the calx of antimony adhering to theſe ſalts. This matter ſeparates and precipitates in form of a very white and fine powder; for which reaſon it has been called *Pearl-Matter*. It has alſo been named the *Ceruſs of Antimony*, and very improperly the *Fixed Sulphur of Antimony*. For it is evident from the nature of the operation, that no ſulphur can remain in it, nor even any inflammable matter. The pearl matter alſo gives no marks of ſulphur contained, and has abſolutely the ſame properties as diaphoretic antimony; and if it differs in any thing, it is in being more perfectly calcined.

The white calx of antimony and the pearl-matter may be reduced into regulus by fuſion in cloſe veſſels, with a reducing flux, as black flux, but only in part, and with conſiderable loſs.

In all theſe operations, where antimony is expoſed to a fuſing heat, a conſiderable quantity of volatile matter riſes in ſmoke, and adheres in form of a meal or fine powder to any cold body it meets. This is called *Flowers of Antimony*, which are nothing elſe than the ſemi-metallic part of the antimony, more or leſs deprived of the ſulphur and phlogiſton; but never entirely of the latter: for which reaſon, they are violently emetic.

In the chemical operations for procuring theſe flowers, only antimony itſelf or its regulus are employed. For this purpoſe a convenient apparatus and veſſels are uſed. *See* FLOWERS *of* ANTIMONY, and FLOWERS *of* REGULUS *of* ANTIMONY.

When crude antimony is boiled in a lixivium of fixed alkali, a liver of ſulphur is formed from the combination of this alkali with the ſulphur of the antimony, by which the metalline part of the antimony is diſſolved. But the alkali, by its being diſſolved in water, having but a ſlight union with the ſulphur, this antimoniated liver of ſulphur cannot be kept ſuſpended in the water, when the heat of that fluid is leſs, or much leſs than is ſufficient to make it boil. Hence when the liquor cools, it becomes turbid; and a brick-colored ſediment falls down, which has been called *Kermes Mineral*. This precipitate drags down along with it, according to a general rule of all precipitates. a portion of the alkali by which it was kept diſſolved. But this portion of alkali is very ſmall. For this reaſon alſo the kermes cannot be kept diſſolved but in very hot water. Hence it appears that kermes is nothing but an antimoniated liver of ſulphur, containing the ſmalleſt poſſible quantity of alkali, or a ſuperabundant quantity of ſulphur and regulus of antimony.

Kermes may alſo be made by fuſion, that is, by melting in a crucible dry alkaline ſalt and crude antimony, and then diſſolving the combination in boiling water. The ſame phenomena appear, as in the preceding operation, and for the ſame reaſons.

Kermes is a preparation of great utility and importance in medicine. *See the details, the preparation of Kermes, and the theory of it more extenſively, as well as its medicinal virtues, at the article* KERMES MINERAL.

Acids difficultly diſſolve regulus of antimony. To diſſolve it by the vitriolic acid, the ſame proceſs muſt be uſed as in the ſolution of mercury by this acid for the preparation of turbith mineral: that is, to employ a very concentrated acid, and to diſtill in cloſe veſſels. The ſame phenomena alſo occur in this operation as in that for turbith mineral: a very ſuffocating ſulphureous acid riſes; and as Mr. Geoffroy obſerves, a true ſulphur ſublimes, and adheres to the neck of the retort: a white ſaline tumefied maſs remains in the veſſel. When the veſſels are unluted, a white fume iſſues like the ſmoking ſpirit of Libavius. Theſe phenomena of the production of volatile ſulphureous acid, and of concrete ſulphur, are evidently effects of the combination of the vitriolic acid with the phlogiſton of the regulus of antimony.

The nitrous acid does, properly ſpeaking, only corrode and dephlogiſticate the regulus of antimony, which it converts into a white calx. It diſſolves a little better this reguline part, when it is applied to the antimony itſelf. This ſolution, as Mr Geoffroy obſerves, acquires a blueiſh greeniſh color. When only a ſufficient quantity of acid is employed, it may be ſeen to inſert itſelf betwixt the ſtriæ of the antimony, and there form ſmall cryſtals.

Marine acid does not ſenſibly act upon antimony nor its regulus. It only detaches from the antimony, in lumps, ſome light and ſulphureous flocks.

Aqua regia moſt directly and completely diſſolves regulus of antimony. For this operation, it is proper to employ an aqua regia compoſed of four parts of ſpirit of nitre, and one part of ſpirit of ſalt. This menſtruum is digeſted in a ſand-bath with a gentle heat upon bits of regulus of antimony, which are added ſucceſſively, ſo that one ſhall not be added till the former are diſſolved. By means of this management, directed by Mr Geoffroy in the Memoirs of the Academy of Sciences, aqua regia can diſſolve about a ſixteenth part of its weight of regulus of antimony. This ſolution has a beautiful golden color, which diſappears by the evaporation of white fumes continually riſing from it.

The aqua regia above deſcribed is alſo very proper to diſſolve the reguline part of crude antimony, and the ſolution even ſucceeds better in this way. This is applicable to all the ſolvents of the regulus of antimony.

The combination of marine acid with regulus of antimony, which ſucceeds ſo ill by applying this acid directly to the ſemi-metal, may be much better made by employing a marine acid previouſly combined with mercury in corroſive ſublimate.

When regulus of antimony or powdered crude antimony is mixed with corroſive ſublimate, and this mixture diſtilled, the marine acid, having a ſtronger affinity with regulus of antimony than with mercury, quits the latter metallic ſubſtance to unite with the former; and from this a combination reſults which paſſes in diſtillation, and has a butyraceous appearance. It is a very corroſive metallic ſalt, and is called the *Butter of Antimony.*

When the regulus is employed to make the butter of antimony, the mercury is ſeparated from the acid of the corroſive ſublimate, and paſſes over in its metallic and fluid ſtate towards the end of the operation, and when the fire is encreaſed.

But if antimony has been employed to make this butter, a cinnabar may be ſublimed, by increaſing the fire after the butter of antimony has paſſed over in diſtillation. This cinnabar reſults from the union of the ſulphur of the antimony with the mercury, and is called *Cinnabar of Antimony. See* BUTTER *and* CINNABAR *of* ANTIMONY.

Butter of antimony is then the reſult of a combination of the metallic part of antimony with marine acid in its higheſt degree of concentration, and is therefore a powerful cauſtic. It may be rendered liquid by a ſmall quantity of water; but if diluted with much water, then the greateſt part of the regulus ſeparates from the menſtruum, and precipitates in the ſtate of a white powder, which has been called *Powder of Algaroth,* and *Mercury of Life. See theſe words.*

The powder of algaroth is a very violent emetic. Mr. Beaumé has aſcertained, by very accurate experiments, that when it is ſufficiently waſhed it does not retain a particle of marine acid.

The liquor in which the powder of algaroth is precipitated contains all the marine acid of the butter of antimony, with a portion of the reguline part, which may be ſeparated from it by precipitation with an alkali. This liquor has been named *Philoſophical Spirit of Vitriol*; which name is improper, ſince it contains no vitriolic acid.

Nitrous acid poured upon butter of antimony diſſolves it eaſily, and even violently. When this ſolution has been made gradually and cautiouſly, a tranſparent ſolution is obtained, impregnated with much regulus of antimony.

As in this operation the added nitrous acid forms with the marine acid, already united with the regulus in the butter of antimony, an aqua regia; and as aqua regia is the beſt ſolvent of this ſemi metallic ſubſtance, a new ſolution takes place by the addition of this nitrous acid, entirely ſimilar, as to its concomitant phenomena, to the ſolutions of metals by this acid, not previouſly diſſolved by any other. This new ſolution is even ſo impetuous, that when the quantity of matter is conſiderable, it is apt to be thrown violently out of the containing veſſels.

Butter of antimony is entirely changed by its union with nitrous acid. This acid, as is uſual, ſeizes upon the inflammable part of the regulus of antimony which the marine had left unchanged: it diminiſhes the adheſion of the marine acid with the regulus. Hence it happens that this new combination of regulus of antimony with the acids of aqua regia, when dried and calcined, no longer poſſeſſes the volatility of the butter of antimony. Inſtead then of ſubliming or paſſing in diſtillation without decompoſition, as the butter does, the new compound reſiſts the action of fire, is decompoſed, lets its acids eſcape, and remains in the ſtate of a white powder.

If freſh nitrous acid be twice poured upon this white powder, and each time the matter evaporated and calcined, the regulus of antimony is then reduced to a white earthy ſubſtance, indiſſoluble in the nitrous acid, entirely fixed and unfuſible, and poſſeſſed of no emetic or purgative qualities. This preparation has been called *Bezoar mineral*. See *this word*.

This operation is one of thoſe which proves moſt ſenſibly the power of the nitrous acid to calcine metallic ſubſtances, by depriving them of their phlogiſton. It alſo proves that it is chiefly by means of this phlogiſton that the nitrous acid diſſolves theſe ſubſtances, ſince it cannot diſſolve bezoar mineral, diaphoretic antimony, nor any other ſimilarly dephlogiſticated metallic ſubſtances.

LXVII. ANNEAL. Annealing conſiſts in making metals red-hot which have become hard and ſtiff by frequent percuſſion, or by a ſtrong compreſſion, in order to reſtore their former malleability and tractability. All metals have the ſingular property of becoming more or leſs hard, untractable, and unmalleable, after they have been ſtruck ſome time with a hammer. It ſeems as if ſomething happened to them ſimilar to the effect produced by the tempering of ſteel. Metals thus affected become more elaſtic than before, but, at the ſame time, more brittle. They are more ſenſibly affected in this manner in proportion as they are naturally harder. Copper is ſo much affected, and even gold and ſilver, by hammering, that they ſoon ceaſe to be malleable, and are apt to ſplit and crack, inſtead of being extended, under the hammer. This labor therefore muſt be often interrupted, to ſoften and reſtore malleability to metals. This is effected by making them red-hot, which the workmen call *annealing*. Thus heat produces the ſame effect on metals in the ſtate deſcribed, as it does upon tempered ſteel: for if the hardeſt tempered ſteel be made red-hot, and cooled ſlowly, it becomes as tractable and ductile as the ſofteſt iron.

There is alſo an annealing for works made of glaſs. It conſiſts in placing them, while newly made and ſti[illegible] hot, in an oven or furnace, where they very ſlowly cool. This annealing for bottles and other glaſs utenſils is quite neceſſary to render them ſerviceable; for all glaſs which is cooled ſuddenly is liable to be broken, not only by the leaſt change of heat and cold, but even by the ſlighteſt force.

LXVIII. APYROUS. This word is applied to denote that property of ſome bodies, by which they reſiſt the moſt violent fire without any ſenſible alteration. Apyrous bodies ought to be diſtingu[illegible]d from thoſe which are *refractory*. Refractory ſubſtances are thoſe which cannot by violent heat be fuſed, whatever other alteration they may ſuſtain. But a body, properly ſpeaking, apyrous, can neither be fuſed by heat, nor can undergo any other change. Hence it follows, that all apyrous ſubſtances are alſo refractory, but that every refractory ſubſtance is not apyrous. Very pure calcareous ſtones, for inſtance, are refractory, becauſe they never melt without addition of other ſubſtance: but they are not apyrous; becauſe by fire their weight is conſiderably diminiſhed, the adheſion of their integrant parts is deſtroyed, and all their eſſential properties are changed by their converſion into quicklime. On the contrary, a very clear and pure diamond is apyrous, becauſe the ſtrongeſt fire is incapable not only of melting it, but alſo of producing upon it any other ſenſible alteration; ſo that a diamond which has been a long time expoſed to the moſt intenſe heat, is found to be the ſame in all reſpects as it was before.

Perhaps there is no body in nature eſſentially and rigorouſly apyrous. This too is very probable; but it is ſufficient that there be bodies apyrous relatively to the degree of fire which art can produce, to entitle them to that name.

LXIX. AQUA-FORTIS. Aqua-fortis is a name given by artiſts and manufacturers to nitrous acid, from its diſſolving power. As it is not the concentrated and ſmoking nitrous acid which is employed in the arts, it ſeems that the name aqua-fortis may be retained by that acid which has not theſe qualities.

Moſt artiſts who uſe nitrous acid, call the purer and ſtronger kind, which is alſo conſiderably dearer, by the name of *Spirit of Nitre*. For the properties of this acid, *ſee* ACID (NITROUS); and for the diſtillation of it, *ſee* SPIRIT of NITRE.

In the manufacture of ſoap, the cauſtic alkaline lixivium is called alſo the *ſtrong water*, or *ſoap-lees*, or *lixivium of ſoap-boilers*. *See* LIXIVIUM.

LXX. AQUA-REGIA. Aqua-regia is a mixture of the nitrous and marine acids. Theſe two acids are mixed to obtain a menſtruum capable of acting upon certain bodies which no pure acid can diſſolve, or but imperfectly: particularly gold and platina cannot be diſſolved in their aggregated ſtate by any other acid than by aqua-regia. Tin and regulus of antimony are better and more eaſily diſſolved by aqua-regia than by any other acid.

This menſtruum may be made either by merely mixing the ſpirit of nitre with ſpirit of ſalt, or by diſſolving in ſpirit of nitre a ſalt containing marine acid, and particularly ſal ammoniac and common ſalt. Laſtly, it may be well made by diſtilling nitrous acid from either of theſe ſalts; becauſe nitrous acid, being capable of diſengaging marine acid from theſe ſalts, does actually diſengage it, either by ſimply diſſolving them in nitrous acid, or by diſtillation.

The only difference betwixt the ſeveral ſorts of aqua-regia, prepared in theſe different manners, is, that the aqua-regia made by merely diſſolving ſal ammoniac or common ſalt in nitrous acid contains ammoniacal or cubic nitre, and that theſe neutral ſalts do not exiſt in the aqua-regia made by mixture of the two acids, or by diſtillation.

The preſence of theſe neutral ſalts in aqua-regia does not injure its diſſolving powers. Thus, as the aqua-regia which contains them is the eaſieſt prepared, and leaſt expenſive, it is more generally uſed than the others. But it is neceſſary to obſerve, that the ammoniacal nitre in the aqua-regia may occaſion conſiderable differences in the nature of the precipitates made from ſolutions of metals in this menſtruum, by ſeparating from theſe precipitates any of thoſe metallic ſubſtances which it is capable of diſſolving, and alſo by a portion of it adhering to precipitates. For inſtance, gold precipitated by a fixed alkali from an aqua-regia made by mixing the pure nitrous and marine acids, does not fulminate; whereas it does fulminate when precipitated from an aqua-regia made by diſſolving ſal ammoniac in nitrous acid. *See* PRECIPITATES; and GOLD (FULMINATING).

The mixture of the nitrous and marine acids preſents a very ſingular and remarkable phenomenon; which is, that the vapors of this mixture are more expanſive and more difficult to be confined than the vapors of either of the acids before mixing. This proves a re-action of theſe acids upon each other. This phenomenon is very little ſenſible when the acids employed contain much ſuperabundant water; but is more manifeſt in proportion as theſe are more concentrated. I have obſerved, that upon mixing moderately ſmoaking nitrous and marine acids, which had remained without occaſioning any diſturbance in their bottles, an aqua-regia has been formed infinitely more ſmoaking, and which has made the ſtopper fly out of the containing bottle, particularly in weather ſomewhat warm. Mr. Beaumé, when diſtilling a pretty ſtrong nitrous acid upon ſal ammoniac, obſerved, that the vapors which paſſed were ſo elaſtic, that notwithſtanding every precaution that could be taken in ſuch a caſe, it was impoſſible to continue the diſtillation.

As to the proportions of nitrous and marine acids, or of ſal ammoniac, which ought to be employed for the preparation of aqua-regia, there are no eſtabliſhed rules. Common aqua-regia is made by diſſolving four ounces of ſal ammoniac in ſixteen ounces of nitrous acid. But theſe proportions ought to be varied according to the nature of the ſolutions intended.

To diſſolve, for example, the greateſt poſſible quantity of platina, the beſt proportion is equal parts of the two acids.

To diſſolve the greateſt quantity of regulus of antimony, the aqua-regia ought to be compoſed of four parts of nitrous acid to one of marine.

In general, the greater the proportion of marine acid, or of ſal ammoniac, is in aqua-regia, the leſs are the imperfect metals, and particularly tin calcined and precipitated by it. An aqua-regia, compoſed of two parts of ſpirit of nitre and one part of ſpirit of ſalt or of ſal ammoniac, makes a clear ſolution of nearly an equal weight of tin, without forming any precipitate: but for this purpoſe, the operation muſt be performed ſlowly, and heat muſt be avoided as much as poſſible. *See* GOLD, PLATINA, TIN, and REGULUS *of* ANTIMONY. (*b*)

LXXI. AQUA-SECUNDA. This is nothing elſe than aqua-fortis diluted with much pure water. It is employed in ſeveral arts to clean the ſurface of metals and of certain ſtones, and for ſome other purpoſes.

LXXII. AQUA-VITÆ. Aqua-vitæ is the ſpirituous part obtained by a firſt diſtillation from wine, or any other liquor which has undergone the vinous fermentation. It is properly ſpeaking, ardent ſpirit, or ſpirit of wine.

To make the aqua-vitæ that is ſold in commerce, wine is put in large copper alembics or ſtills, to which worms are fitted, and the diſtillation is ſo conducted

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(*b*) Aqua-regia does not diſſolve ſilver: but when the quantity of marine acid contained in the aqua-regia is very ſmall, the acid of nitre does then diſſolve ſilver, which is immediately afterwards attacked by the marine acid, with which it forms the metallic ſalt called *luna cornea*, and is precipitated. Aqua-regia diſſolves a larger quantity of lead than marine acid. All the other metals it perfectly diſſolves. According to Gellert's table, the ſubſtances which aqua-regia diſſolves are placed in the following order, beginning with thoſe to which it moſt powerfully unites: Phlogiſton, zinc, iron, regulus of cobalt, copper, tin, arſenic, biſmuth, mercury, lead, regulus of antimony, gold. In this table copper is erroneouſly placed before tin, as the latter metal readily precipitates the former.

that the liquor flows out of the beak of the ſtill in a conſtant ſtream, and is continued till this liquor begins to be no longer inflammable.

It is evident that this diſtillation, being haſtily and unartfully performed, can only furniſh a very impure ſpirit of wine, mixed with ſeveral of the other principles of the wine employed. Thus aqua-vitæ contains much ſuperabundant water, and much oil of wine, ſubſtances entirely foreign to what is properly called ſpirit of wine.

Theſe heterogeneous matters contained in aqua vitæ prevent it from being employed in chemical operations. To purify it, and change it into ſpirit of wine, it muſt be again diſtilled and rectified. *See* SPIRIT *of* WINE.

LXXIII. AQUILA ALBA. (c)

LXXIV. ARBOR DIANÆ. The arbor Dianæ is the reſult of a chemical operation by which particles of ſilver, previouſly diſſolved in nitrous acid, are capable of arranging themſelves in the form of a ſhrub. Chemiſts have called this *Arbor Dianæ*, from the ſilver which they alſo call Diana or the Moon. The following proceſs given by Lemeri for making the arbor Dianæ ſucceeds well:

“ Take an ounce of fine ſilver, diſſolve it in a ſufficient quantity of ſpirit of
“ nitre, very pure and moderately ſtrong; mix this ſolution of ſilver in a mat-
“ traſs with about twenty ounces of diſtilled water; add to this mixture two
“ ounces of mercury, and let the whole remain at reſt. During a ſpace of about
“ forty days, a kind of ſilver tree will be formed upon the mercury, with
“ branches reſembling vegetable ramifications.”

As this proceſs is very long, we ſhall here add another much ſhorter, taken from a memoir of Mr. Homberg, and quoted by Mr. Baron, in his edition of Lemeri's Chemiſtry.

“ Make an amalgam without heat, of four drams of filings of ſilver, or, ſtill
“ better, of ſilver-leaf, and of two drams of mercury (*See* AMALGAM); diſ-
“ ſolve this amalgam in four ounces, or a ſufficient quantity, of ſpirit of nitre
“ pure and moderately ſtrong; dilute this ſolution in about a pound and a half
“ of diſtilled water; ſhake the mixture, and preſerve it in a bottle with a glaſs
“ ſtopper: when this preparation is to be uſed, an ounce of it is to be put into a
“ phial together with about the ſize of a pea of an amalgam of gold or of ſilver,
“ which ought to be ſoft as butter; and the whole is to remain at reſt: ſoon
“ afterwards, ſmall filaments are to be ſeen iſſuing from the ſmall amalgam,
“ which quickly encreaſe, branch out on both ſides, and take the form of
“ ſhrubs.”

This experiment, which is generally conſidered merely as curious and amuſing, is founded on many of the eſſential properties of the ſubſtances employed. As mercury has a ſtronger affinity than ſilver to nitrous acid, it obliges this metal to ſeparate and precipitate. But in this precipitation there are two eſſential particulars: the firſt is the color of the ſilver precipitated, which on this occaſion appears in its natural form and metallic brilliancy. The cauſe of this is, that it was precipitated by a metallic ſubſtance; for it appears, that in general this happens whenever one metal is precipitated by another metal; whereas metals precipitated by any other ſubſtance are always in form of calxes, or earthy precipitates, without any metallic appearance. *See* PRECIPITATION.

(c) AQUILA ALBA is a name given to ſweet mercury. *See* MERCURY (SWEET).

The ſecond remark to be made on the precipitation of ſilver in this experiment is, the ſingular arrangement taken by the particles of ſilver on the ſurface of the mercury one after another, according as they are ſeparated from the nitrous acid. We cannot but perceive in this phenomenon a very ſenſible effect of the attraction or affinity of the integrant parts of the ſame ſubſtance, or of two ſimilar ſubſtances to each other. In fact, it can only proceed from this affinity which the particles of ſilver firſt ſeparated from the nitrous acid have with the mercury, that they rather attach themſelves to the ſurface of that metallic ſubſtance, than to any part of the veſſel or of the liquor; and it alſo proceeds from this tendency which the particles of ſilver have to each other, that thoſe which are afterwards ſeparated from the nitrous acid adhere to the particles already attached to the mercury, and to each other, rather than to any other body.

As to the neceſſary conditions for this experiment of the arbor Dianæ, it has been already recommended to employ very pure ſilver, nitrous acid, and water, becauſe the greateſt part of the extraneous matters with which theſe ſubſtances are generally mixed, are capable of precipitating the ſilver, which in the preſent experiment ought not to be ſeparated but by mercury. *See* SILVER, and PARTING.

In the ſecond place, it is abſolutely neceſſary to dilute in much water the ſolution of ſilver; 1. To avoid the formation of cryſtals of ſilver, which might take place if this ſolution was too concentrated, theſe being a cryſtallization of ſilver in a ſaline ſtate, very different from the arbor Dianæ which is required. *See* CRYSTALS *of* SILVER. 2. Becauſe if the ſolution of ſilver was concentrated, the particles of ſilver would be precipitated too faſt, and in too great quantity; by which they would be prevented from applying themſelves regularly to each other, and would be thrown down confuſedly.

In the third place, it is neceſſary that the nitrous acid ſhould be ſaturated with ſilver before it is diluted with water, otherwiſe the unſaturated part of the acid muſt firſt diſſolve its proper quantity of ſilver or mercury, before the precipitation can take place, which would lengthen the experiment ſo much more, as the quantity of water with which the ſolution was diluted was greater.

LXXV. ARCANUM CORALLINUM. This is nothing elſe than *red precipitate*, on which ſpirit of wine has been two or three times burnt, with an intention of rendering it milder. *See* PRECIPITATE (RED).

LXXVI. ARCANUM DUPLICATUM. This Latin name, which ſignifies *the double ſecret*, is one of the moſt generally known ſalts. It is the ſalt compoſed of vitriolic acid united with vegetable fixed alkali, and therefore does not differ from the *Sal de duobus*, and *vitriolated tartar.* [illegible] TARTAR (VITRIOLATED).

LXXVII. ARCHIL. (*d*)

(*d*) ARCHIL, ARCHILLA, ROCELLA, or ORSEILLE, is a white moſs which grows in the Canary and Cape de Verd iſlands, and according to *Linnæus*, on the weſtern coaſt of England. From this plant is prepared by grinding and moiſtening with volatile alkali, a beautiful purple dye, which is not durable, but is chiefly uſed to give a bloom as it is called,

LXXVIII. ARGENTUM MUSIVUM. (e)

LXXIX. ARRACK. (f)

LXXX. ARSENIC. Arſenic, or *white arſenic*, is, properly ſpeaking, nothing but the flowers or calx of regulus of arſenic.

This ſubſtance has ſingular properties, which render it the only one of its kind.

It is at once a metallic earth and a ſaline ſubſtance. It reſembles all metallic calxes in its capacity of combining with phlogiſton, and of being thereby changed into a true ſemimetal.

But it very eſſentially differs from all metallic calxes and earths.

1. In being conſtantly volatile; whereas all other calxes of metals, and even of the moſt volatile ſemimetals, are very fixed when deprived of phlogiſton

2. Metallic calxes, ſo far from being ſoluble in water, are even for the moſt part indiſſoluble in the ſtrongeſt acids. White arſenic, on the contrary, is ſoluble, not only in all acids, but alſo in water itſelf, as ſaline matters are.

According to Mr. Brandt, (*Acta Eruditorum Upſal. de Semimetallis*, 1733) arſenic may be diſſolved in fourteen or fifteen times its weight of water, by help of a boiling heat, and tranſparent yellow cryſtals may be obtained by evaporating this ſolution.

3. Metallic calxes, when perfectly calcined, (the calx of the regulus of antimony not excepted) are entirely free from ſmell, taſte, or other action upon the human body. On the contrary, arſenic always preſerves a ſtrong alliaceous ſmell, and when put on the tongue, it excites an impreſſion of acrimony and heat, which produces an involuntary ſpitting; when taken internally, or even when applied externally, it produces the moſt terrible and violent effects of a corroſive poiſon.

4. No kind of earth, nor even the metallic earths, can contract an union with metallic ſubſtances. Arſenic eaſily unites with all metals and ſemimetals, with the ſame degrees of affinity that the regulus of antimony does, that is to ſay, in the order following, according to Mr. Cramer: Iron, copper, tin, lead, ſilver, gold.

It is proper to obſerve, that arſenic renders all the metals with which it is united brittle. It renders gold of a greyiſh color in its broken ſurface, ſilver of a deep grey, and copper white. Tin becomes by mixture with arſenic much harder and more unfuſible. Lead becomes very hard and very brittle, and it changes iron into a blackiſh maſs. Theſe obſervations are taken from Mr. Brandt's Memoir quoted above.

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called, to other colors. By adding ſolution of tin to an infuſion of archil in water, a durable ſcarlet dye is produced, as Mr. Hellot ſays. The color of archil may be extracted by water, by volatile ſpirits, or by ſpirit of wine. It loſes its color in glaſs tubes hermetically ſealed, and reſumes it upon expoſure to air. A ſolution of archil in water gives a permanent and deep ſtain of a purpliſh color to marble.

(e) **Argentum Musivum** or **Mosaicum** is a maſs conſiſting of ſilver-like flakes, uſed for the coloring of plaſter figures, and for other purpoſes, as a pigment. It conſiſts of an amalgam of equal parts of tin, biſmuth, and mercury. It is to be mixed with white of eggs, or ſpirit varniſh, and then applied to the intended work, which is afterwards to be burniſhed.

(f) **Arrack** is a vinous ſpirit obtained by diſtillation in the Eaſt-Indies, from rice or ſugar, as is ſaid, fermented with the juice of cocoa nuts.

5. The more metallic calxes are deprived of phlogiſton, the more unfuſible they are rendered. On the contrary, arſenic is always very fuſible. Its volatility alone prevents its perfect fuſion. It volatilizes, vitrifies, and ſcorifies all ſolid bodies, excepting gold, ſilver, and platina.

6. Earths and metallic calxes have no action upon nitre, which (as is obſerved under the article *Nitre*) can be decompoſed only by phlogiſton, by vitriolic acid, and by ſedative ſalt. Arſenic decompoſes nitre with the greateſt facility, not by combining with and deſtroying its acid, as phlogiſton does; but by diſengaging it, and uniting in its place with the alkali, as the vitriolic acid and ſedative ſalt do.

Stahl and Kunkel both knew this property which arſenic poſſeſſes of decompoſing nitre, and of diſengaging its acid.

Stahl directs how to prepare by means of arſenic a very volatile nitrous acid, extremely concentrated, of a penetrating fetid ſmell, and blue color, although its vapors are red. This color, according to Mr. Beaumé's obſervation, is cauſed by the water which muſt neceſſarily be put in the receiver to condenſe the vapors of this very ſtrong and difficultly condenſible acid.

Kunkel alſo directs to make an aqua-fortis ſimilar to that of Stahl, but by a much clearer and ſimpler proceſs, ſince he decompoſes nitre by arſenic alone; whereas Stahl employs in his mixture a martial vitriol calcined till it becomes red, and does not uſe pure arſenic, but a combination of equal parts of arſenic with antimony and ſulphur, a combination which the chemiſts have called *Pirmieſon*, or *Lapis de tribus*.

Theſe two chemiſts contented themſelves with examining the properties of the ſpirit of nitre, which they procured by means of arſenic, and nobody had examined the reſiduum in the retort after diſtillation.

This matter, being worthy of attention, has been reſumed by Mr. Macquer, who has particularly examined the decompoſition of nitre in cloſe veſſels by arſenic, and the new kind of ſalt remaining in the retort after the diſtillation of the nitrous acid.

Theſe reſearches, the detail of which has been given in two memoirs printed in the collection of the academy, diſcovered to him that arſenic, by combining with the baſis of nitre, after having chaſed the acid from it, forms with this alkali a kind of ſalt perfectly neutral, which he has called *neutral arſenical Salt*. *See* SALT (NEUTRAL ARSENICAL).

Another decompoſition of nitre by arſenic was known by chemiſts, and conſequently alſo another combination of arſenic with the baſis of nitre, called by ſome chemiſts, *Arſenic fixed by Nitre*, or *Nitre fixed by Arſenic*; but this latter combination differs from the arſenical ſalt of Mr. Macquer in this, that it is not a neutral ſalt, and that it preſerves, on the contrary, all the properties of an alkali. *See* NITRE FIXED *by* ARSENIC.

Mr. Macquer has alſo made another combination of arſenic with deliquiated fixed alkali. Mention is made of it alſo under the article *Salt (Neutral Arſenical)*. There the differences are ſhewn betwixt theſe two combinations, although formed of the ſame ſubſtances.

White arſenic, although very volatile, is partly fixed by the adheſion which it contracts with different ſorts of earths, and even ſo far as to ſuſtain a vitrifying heat. It facilitates the fuſion of many refractory matters; hence it enters into the compoſition of ſeveral glaſſes, to which it gives much whiteneſs and cleanneſs, nearly in the ſame manner as borax and the ſedative ſalt do: but it alſo has the ſame inconvenience, namely, that glaſs, in which a conſiderable portion of arſenic enters, is very quickly corroded by the air.

Dyers employ white arſenic in ſeveral of their operations; but the effects it produces are not yet well known, and require a particular examination. Arſenic and its regulus, being capable of combining with all metals, is employed for ſeveral metallic compoſitions; ſuch, for inſtance, as *white copper*, and *white tombac*. *See* theſe words.

Arſenic is employed ſucceſsfully for making, together with copper and tin, metallic compounds of a beautiful white color, and of a very denſe and cloſe texture, and conſequently capable of receiving a fine poliſh, of reflecting well the rays of light, and of being formed into metallic mirrors.

From what has been ſaid concerning the properties of arſenic, we may conjecture that this ſubſtance is a metallic earth of a particular nature, intimately combined with a ſaline and even acid principle, which has never been ſeparated from it by any chemical trial, which accompanies it in its combination with phlogiſton when it takes a metallic form, and which adheres to it when, by the burning of this phlogiſton, it becomes again white arſenic.

Thus Becker, without having been acquainted with all the properties of white arſenic, gives an idea of it very analogous to this conjecture. He defines it in his *Subterranean Phyſics*, "a ſubſtance compoſed of the earth of ſulphur which "is in common ſalt," (by which he ſeems to mean the acid of ſea-ſalt) "and "of a metal joined to it." In another place, he calls it "a coagulated aqua-fortis." And as he imagined he could trace every where his mercurial earth, or at leaſt ſomething mercurial, he calls mercury a fluid arſenic. He conſiders mercury, and metals precipitated by marine acid, for inſtance, *luna cornea*, as different kinds of artificial arſenic.

Arſenic combines with ſulphur, and forms with it a compound of a yellowiſh tinge, more or leſs red according to the quantity of ſulphur with which it is united. It is of a beautiful yellow color when the ſulphur is only a tenth part of the mixture, and is then called *yellow arſenic*: when the ſulphur is a fifth part of the mixture, it is of a very beautiful red color, and it is then called *red arſenic*. The mixture of ſulphur renders it a little more fixed and more fuſible. Thus red arſenic may be melted, and by this means acquires tranſparency: it then reſembles a ruby, [illegible] or *arſenical ruby*.

All theſe compounds of arſenic and ſulphur are arti[illegible]. They are prepared by mixing and ſubliming theſe two ſubſtances together in the proportions abovementioned, or, ſtill better, in ſubliming together the ſulphur an[illegible]ic of minerals containing theſe two ſubſtances.

Natural compounds are alſo found, which are combinations of ſulphur and of arſenic, nearly of the ſame colors as the red and yellow artificial arſenics. They come from the Eaſt, from Tranſylvania, and Turkey. The yellow are called *orpiment*, *orpin*, and *yellow rizigal*: the red are called *ſandarach*, *realgar*, or *red rizigal*.

Agricola, Mathiole, Schroder, ſeem to have confounded the red and yellow artificial arſenics with the native; and after them moſt chemiſts and naturaliſts have alſo confounded them; a confuſion for which they have been reproached by Hoffman, chiefly becauſe he was convinced that native orpiment and realgars are not poiſonous, like the yellow and red artificial arſenics, from experiments which he had made on purpoſe.

On this ſubject we muſt remark, that, notwithſtanding Hoffman's experiments, which were made only once or twice upon dogs, it would be very imprudent to give the native orpiment or realgars internally: particularly as all chemical trials ſhow that they contain an arſenical principle; and that Hoffman himſelf agrees, that when they have been expoſed to fire, they become very violent poiſons.

Hoffman alſo remarks, that the ancient phyſicians did not ſcruple to give internally orpiment and realgar, and juſtifies them from the reproaches thrown upon them by moderns. But we muſt obſerve, that the ancients were unacquainted with white, red, and yellow arſenics, which have been well known only within theſe two hundred years; and that if they had known the effects of theſe poiſons, and their reſemblance to the native orpiments and realgars, they would probably have been leſs bold. Diſtruſt is as commendable as boldneſs is blameable in thoſe matters, the almoſt inſenſible differences of which may occaſion the moſt troubleſome accidents. For this reaſon, we cannot approve of the ſingular ſecurity with which ſo great a phyſician, as Hoffman was, endeavors to inſpire a confidence for ſo ſuſpicious drugs as native orpiment and realgar.

We do not however mean to ſay, that there is no eſſential difference betwixt native orpiment and yellow arſenic. It is even agreed that the arſenic contained in the orpiment is better united with the ſulphur, and is beſides in a leſs proportion: for one part of orpiment appears to be compoſed of a ſparry ſtone and mica, from which it receives a foliated and ſhining form.

When arſenic is combined with ſulphur, a part of the ſulphur may be ſeparated from it merely by ſublimation, becauſe it is more volatile. But ſome of the ſulphur always remains united with the arſenic, from which it cannot be ſeparated but by an intermediate ſubſtance.

Fixed alkali and mercury are two intermediate ſubſtances proper for this operation.

When fixed alkali is uſed, it muſt previouſly be deliquiated or reſolved into a liquid, and with this the ſulphurated arſenic is to be made into a paſte. This paſte is to be ſublimed in a proper veſſel with a heat gradually raiſed. The arſenic then ſublimes in white flowers. When too much alkali is added, leſs arſenic is obtained: becauſe ſome of the arſenic is retained by the part of the alkali which is unſaturated with ſulphur. A liver of ſulphur is found at the bottom of the veſſel after the operation.

When mercury is employed for this ſeparation, it muſt be triturated and mixed with the ſulphurated arſenic, and the mixture ſublimed. Firſt the arſenic riſes, then cinnabar. All the metallic matters which have a ſtronger affinity than mercury to ſulphur may ſeem capable of being employed for this purpoſe; but there are two objections.

1. They have alſo a conſiderable affinity with arſenic, and mercury has none.

2. Arſenic has the remarkable property of taking from all metallic matters, excepting gold, ſilver, and mercury, a part of their phlogiſton; ſo that it would be ſublimed half reguliſed.

In the operation by mercury, a part of the cinnabar frequently riſes with the arſenic; which makes it neceſſary to ſublime it a ſecond time.

Arſenic is ſoluble in all acids, and with them forms combinations which have not yet been ſufficiently examined. The vitriolic acid has the property of rendering it much more fixed than it naturally is: an effect which it alſo produces upon mercury.

If a mixture of arſenic and concentrated vitriolic acid be diſtilled together, a vitriolic acid is obtained, which, as Mr. Macquer obſerves, has ſometimes the exact ſmell of marine acid. When this ſolution is diſtilled till no more acid riſes, the retort is then almoſt red-hot, and no arſenic is ſublimed; but it remains fuſed at the bottom of the retort; and when it is cold, it is found to be one heavy, compact maſs, brittle and tranſparent as cryſtal-glaſs. This kind of arſenical glaſs expoſed to the air ſoon loſes its luſtre from the moiſture it attracts, which diſſolves and partly deliquiates it. This deliquium is extremely acid.

Arſenic treated with phlogiſton in a proper manner combines with it, and aſſumes all the properties of a very volatile ſemi-metal, of a white ſhining color, more or leſs upon the grey. This ſubſtance is called *Regulus of Arſenic. See this word for the manner of making this regulus, and for its properties.*

The arſenic ſold in commerce is brought chiefly from the cobalt works in Saxony for making *Zaffer*, and *Smalt*. Cobalt contains much arſenic, which muſt be ſeparated from it by a long torrefaction, and which would be loſt but for a particular contrivance for the collecting it.

For this purpoſe, cobalt is roaſted in a vaulted oven, to which is adjuſted a long crooked chimney. The arſenic in vapors paſſes along this chimney, and is there collected; the arſenic which attaches itſelf to the coldeſt and moſt diſtant part of the chimney is in form of a white or grey powder, called *Flowers*, or *Meal of Arſenic*; whereas that part of the arſenic which adheres to the hotteſt part of the chimney, and leaſt remote from the furnace, ſuſtains there a kind of fuſion by which it is reduced into compact, heavy, white maſſes reſembling white enamel. Theſe maſſes of white arſenic are almoſt always interrupted by yellow or greyiſh veins and ſtrata. Theſe colors proceed from a little ſulphur or phlogiſton with which this part of the arſenic is ſtill united.

As arſenic is ſeldom obtained in the great works entirely free from ſulphureous or phlogiſtical particles, if it be required perfectly pure in operations of chemiſtry or of arts, it muſt be again ſublimed after mixing it with ſome intermediate ſubſtance capable of abſorbing its inflammable parts, ſuch as fixed alkali or abſorbent earth.

Arſenic is a very violent corroſive poiſon: it produces always the moſt painful ſymptoms and fatal effects, whether it be taken internally or applied externally. It ought never to be employed medicinally, although ſome people, not very intelligent, give ſmall doſes of it in obſtinate intermittent fevers, which it effectually cures, but is always attended with bad conſequences to the patients, ſuch as phthiſis, and other no leſs troubleſome diſeaſes.

Perſons poiſoned by arſenic ſuffer acute pains in their bowels, violent vomitings, cold ſweats, ſyncopes, and convulſions, which are always followed by death, unleſs prevented by ſpeedy remedies. The beſt antidotes to this poiſon are large quantities of diluting and ſoftening drinks, as mucilages, oil, milk. Perhaps abſorbent and alkaline matters would alſo produce good effects, from the property which arſenic has of combining with, and in ſome meaſure of being neutralized by, theſe ſubſtances.

When the bodies of perſons killed by arſenic are examined, their ſtomachs and inteſtines are found covered with red, black, livid, inflamed and gangrenous ſpots. Frequently alſo arſenic is found there in ſubſtance, which may eaſily be diſtinguiſhed by its alliaceous ſmell, when put on burning coals, or a red-hot iron.

Mr. Geoffry's table does not ſhew the affinities of arſenic. In Mr. Gellert's they are zinc, iron, copper, tin, lead, ſilver, gold, and regulus of antimony. (g)

LXXXI. ASA-FŒTIDA (h)

LXXXII. ASBESTUS. (i)

LXXXIII. ASHES. This name is generally applied to the ſubſtance remaining of bodies containing an inflammable matter, of which they have been deprived by burning, or calcination in open air. Thus workmen, without underſtanding chemiſtry, and induced merely by analogy or reſemblance, apply the name of *aſhes* to metallic earths thus calcined. Pewterers, for example, give the name *Tin-aſhes*, to the earth of this metal which in fuſion has been deprived of its phlogiſton and metallic properties. If workmen had always applied names as properly as they have done this, they could not have been blamed. *See* COMBUSTION.

(g) *Neuman* relates that arſenic precipitated almoſt all metallic ſolutions, but moſt of them very ſlowly. Silver, iron, copper, tin, lead, mercury, biſmuth, were precipitated from aqua fortis, and gold from aqua regia. Solutions of mercury corroſive ſublimate, of copper in aqua regia, of zinc in aqua-fortis, and of regulus of antimony ſuffered no precipitation. Solutions in vitriolic acid of zinc and of iron were precipitated, of copper very little. Sugar of lead, and ſolutions of ſulphur with quicklime or fixed alkali were precipitated. The ſame author further relates, that arſenic was not precipitated from its ſolution in vitriolic or nitrous acids by oil of tartar or by volatile alkali, but it was precipitated from marine acid by oil of tartar.

Arſenic is uſed for many purpoſes; by dyers, as an ingredient in compoſitions for ſcarlets and other fine reds; by goldſmiths, for enamelling; by makers of glaſs, for promoting the fuſion of fritt, and the clearneſs and tranſparency of glaſs; by potters, for a white glazing; by eſſayers, in form of glaſs, for promoting the ſcorification of ores which contain tin and antimony, for the preparation of compound metals, and for whitening copper and braſs. *Neuman* ſays, that a beautiful metal like the fineſt ſteel may be made by melting caſt iron with arſenic, glaſs, and a little tin; and that a metal reſembling ſilver may be made from iron, tin, arſenic, and perhaps a little copper. Mr. Brandt (*Act. Upſal.* 1733) propoſes to make a varniſh for ſhips, of arſenic with pitch, ſulphur, or roſin, to preſerve the timber from rotting, and from worms.

(h) ASA-FOETIDA is a gum-reſin, from four ounces of which rectified ſpirit is capable of extracting two ounces ſix drams and a half of reſinous extract; and water, one ounce three ſcruples and a half of gummy extract. Four ounces of aſa-fœtida, diſtilled either with water or with ſpirit, yielded above a dram of eſſential oil, in which its peculiar ſmell reſides. *Neuman.*

(i) ASBESTUS is a grey, greeniſh or blackiſh ſtone, poſſeſſed of the ſame chemical properties as amianthus, and is therefore referable to the ſame claſs of earths. *See* AMIANTHUS. The chief differences betwixt thoſe two ſtones are, that asbeſtus is heavier than amianthus, and its fibres are more hard and brittle.

Falſe asbeſtus is a name given to plume-alum. *See* ALUM (PLUME)

LXXXIV. **AS[illegible]OLE.** The aſh-hole is the loweſt part of a furnace, and is intended to re[illegible] the aſhes falling from the fire, and to give a paſſage to the air which is [illegible] introduced into the furnace, to keep up the combuſtion. *See* FURNACE.

LXXXV. **ATHANOR.** Chemiſts have diſtinguiſhed by this name a furnace ſo conſtructed that it can always maintain an equal heat, and which ſhall laſt a long time without addition of freſh fuel.

The body of the athanor has nothing in it particular, and is conſtructed like ordinary furnaces. But at one of its ſides, or its middle, there is an upright hollow tower, which communicates with the fire-place by one or more ſloping openings. This tower ought to have a lid which exactly cloſes its upper opening.

When the athanor is to be uſed, as much lighted coal is put in the fire-place as is judged neceſſary, and the tower is filled to the top with unlighted fuel. The tower is then to be exactly cloſed with its lid. As faſt as the coal in the fire-place is conſumed, that in the tower falls down and ſupplies its place. As the coal contained in the tower has no free communication with the external air, it cannot burn till it falls into the fire-place.

The athanor being much celebrated and uſed by ancient chemiſts, it has been particularly deſcribed by many authors, and was formerly found in all laboratories. At preſent this furnace is much leſs employed, and is even neglected. The reaſon of this is, that all the ancient chemiſts were in ſearch of the art of making gold; and being excited by this powerful deſire, and confidence of ſucceſs, they ſpared no trouble nor expence to accompliſh their deſign. They undertook without heſitation, operations which required great length of time and unremitted l[illegible]. Whereas now, theſe alluring hopes having vaniſhed, the cultivators of chemiſtry have no other view than to extend and perfect the theory of this eſſential part of natural philoſophy. This motive, although undoubtedly much nobler than the former, ſeems however to be leſs powerful over moſt men. For now, all long and laborious operations whence chemiſtry might receive great advantages, are neglected, as being tireſome and diſguſtful. There is, in fact, a conſiderable difference betwixt the hope of explaining a philoſophical phenomenon, and that of obtaining an ingot of gold capable of producing many others. Hence the inſtruments employed in long operations, and particularly the athanor, are now much neglected; and alſo becauſe the fuel in the tower is apt to ſtick there or fall down at once in too great quantity. The *Lamp-furnace*, which is a true athanor, may be ſucceſsfully employed in operations which do not require much heat. *See* FURNACE (LAMP). (k)

LXXXVI. **AURUM MOSAICUM.** (l)

LXXXVII. **AZURE.** The word azure, which at preſent ſignifies in general a fine blue color, was formerly appropriated to *Lapis Lazuli*, called

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(k) *See* PLATES.

azure-ſtone, and to the blue prepared from it. But ſince a blue has been extracted from cobalt, cuſtom has applied to it the name of azure, although it differs conſiderably from the former, and is incapable of being uſed for the ſame purpoſes, and particularly for painting in oil. The former at preſent is called *Lapis Lazuli*, or only *lapis*, and the blue prepared from it for painting in oil, is called *Ultramarine*.

The name *azure* is generally applied to the blue [illegible] made from the earth of cobalt and vitrifiable matters. This glaſs, which [illegible] called *Smalt* when in maſſes, is called azure only when it is reduced to a fine powder. Several kinds of azure are diſtinguiſhed, according to its degrees of beauty, by the names of *Fine Azure*, *Powdered Azure*, and *Azure of Four Fires*. In general, the greater the intenſity of color and the fineneſs of powder, the more beautiful and dear it is. Azure is employed to color ſtarch; hence it has alſo been called *Starch-Blue*. It is uſed for painting with colors and for a blue enamel. *See* COBALT, SMALT, ZAFFRE. *See alſo* LAPIS LAZULI.

(*l*) AURUM MOSAICUM, or MUSIVUM, is a maſs conſiſting of beautiful gold-colored flakes, prepared by amalgamating tin with half its quantity of mercury, mixing this amalgam when cold with half its quantity of ſal ammoniac, and the ſame quantity of flowers of ſulphur, and by expoſing the whole mixture to fire in a matraſs, by which means a ſal ammoniac and cinnabar will be ſublimed, and the reſiduum is the aurum moſaicum, or moſaic gold, weighing about $\frac{1}{3}$ more than the tin originally employed. It is uſed as a pigment and for mixing with glaſs to imitate the ſpangles of lapis lazuli; for which latter purpoſe ſhining talk is alſo employed.

B.

LXXXVIII. BALANCE (HYDROSTATICAL). The hydroſtatical balance is an inſtrument by which the ſpecific gravity of bodies is determined. For this purpoſe it is neceſſary to find how much any given weight of a body, whoſe ſpecific gravity is required, loſes of its abſolute gravity when plunged into a fluid. All liquid ſubſtances are proper to determine ſpecific gravities, becauſe theſe gravities are only relative : but water has been generally employed for this purpoſe, becauſe it is the moſt common liquid, and moſt conſtantly of a nearly uniform weight.

When a body is to be weighed in water, it is ſuſpended to one of the arms of a balance, to the other arm of which is fixed an ordinary ſcale, and in this ſcale weights are to be put ſufficient to maintain an equilibrium with the body ſuſpended in air. The weight neceſſary for this purpoſe is to be obſerved and remembered. Then the ſame body ſtill ſuſpended at the arm of the balance, and counterpoiſed by the weights in the ſcale, is to be immerſed in water, by which the equilibrium is deſtroyed, and the balance inclines to the ſide of the weights. The weights are therefore to be diminiſhed till an equilibrium is reſtored with the body ſunk entirely in water. The difference betwixt the weights of the ſame body weighed in air and in water, determines its ſpecific gravity.

It is proper to obſerve upon this ſubject, 1. That water can determine the ſpecific gravity of bodies only which are ſpecifically heavier than itſelf. For it is certain, that if they were lighter than water they could not ſink in it by their own weight, which is neceſſary for the experiment. In this caſe it is neceſſary to employ ſome liquid lighter than water, ſuch as ethereal oils, ſpirit of wine, or ether.

2. It is proper to remark on the ſubject of the hydroſtatical balance, that it can be employed conveniently for ſolid bodies only, becauſe the fluids cannot be weighed in water but by means of ſome veſſel which muſt be immerſed along with them. But this veſſel having its peculiar ſpecific gravity would render a troubleſome calculation neceſſary. Another method is then generally uſed to determine the ſpecific gravity of liquids.

3. If the ſolid body, whoſe ſpecific gravity is to be determined, be ſoluble in water, as, for inſtance, a lump of ſalt, water could not be employed for this experiment, becauſe a quantity of it would be diſſolved during the time of weighing ; by which an error would be occaſioned ſo much greater as there was more

of the ſoluble body diſſolved. In this caſe then it is neceſſary to uſe ſome other liquid which cannot diſſolve the body, or elſe not to employ the hydroſtatical balance, but the ſame method by which the ſpecific gravity of liquids is diſcovered. *See* GRAVITY, GRAVITY (ABSOLUTE), GRAVITY (SPECIFIC).

LXXXIX. BALLS (MARTIAL). Martial Balls are a mixture of filings of iron and of cream of tartar formed into a ſolid conſiſtence and form of a ball, which is uſed to impregnate water or other liquids with iron diſſolved by the tartareous acid. To make theſe balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron veſſel with ſome water. This mixture is to be ſtirred from time to time, till it becomes almoſt dry, and then it is to receive more water, and to be ſtirred as before. This treatment is to be continued till it acquires, when nearly dry, ſomewhat of the conſiſtence and tenacity of ſoftened roſin. Then it is to be rolled up into the form of a ball, which is generally kept tyed up in a rag, and when intended to be uſed, it is to be infuſed in water, till it gives ſome color to that liquid.

The infuſion of martial balls is tonic, vulnerary, diſcutient, and aperitive; and is employed both internally and externally. *See* IRON.

Iron being ſoluble in all acids, is attacked in this preparation by the tartareous acid, which reduces it to a kind of neutral ſalt not cryſtallizable. This ſalt would remain liquid, and would form a *ſoluble martial tartar*, called *Tartariſed Tincture of Mars*. If proper proportions of filings of iron and cream of tartar be uſed, and treated long enough for an entire and complete combination, nothing would be obtained but a liquor or *magma*, which could not be preſerved in a ſolid form, but would be continually moiſt. Therefore in the martial ball there is a good deal of the cream of tartar and filings of iron not combined together, by which its ſolidity is preſerved.

Hence it follows that the infuſion of the martial ball is entirely of the ſame nature as the tartariſed tincture of Mars; and therefore theſe preparations may be ſubſtituted for each other. *See* TINCTURE *of* MARS (TARTARISED).

XC. BALLS (M[illegible]CURIAL). Mercurial balls are an amalgam of mercury and tin, ſufficiently ſolid to be moulded, and to preſerve a given form.

The method of making them is by adding mercury to melted tin, and pouring the fluid maſs into a round and hollow mould.

Theſe balls are employed to purify water, in which they are boiled; for which purpoſe travellers often carry ſome along with them.

XCI. BALLOON. This name is given to glaſs bottles, or receivers, which are generally round like hollow ſpheres, or like foot-balls, called in French, *Balons*, whence they are named.

In a laboratory there ought to be balloons of different ſizes, capable of containing from a quart of water to fifteen or twenty pints. The large balloons are employed in diſtillations in great, being capable of containing much, and having necks wide enough to admit thoſe of large retorts. For the contrary reaſons, ſmall balloons are employed wh[illegible] little matter is to be diſtilled.

Large balloons are alſo neceſſary when the vapors diſengaged during the diſtillation are very elaſtic and difficult to be condenſed; becauſe ſuch vapors would not find in ſmall veſſels ſufficient ſpace to circulate and condenſe; hence they would either burſt the veſſel, or if a vent was given them to prevent that accident, they would be entirely diſſipated and loſt. Notwithſtanding the ſize of the balloons employed, ſo much air is diſengaged during the diſtillation of certain hard bodies, vegetable and animal, ſuch as wood, tartar, hartſhorn, &c. and the vapors of certain acids, ſuch as the ſmoking ſpirits of nitre and of ſea-ſalt, are ſo elaſtic and expanſible, that a ſmall hole in the ſide of the balloon is neceſſary to give vent to thoſe vapors when neceſſary. Afterwards this hole, which ought to be about half a line in diameter, is to be cloſed with a peg of wood, or ſome lute.

It is to be wiſhed, that in the glaſs-houſes where chemical veſſels are made, it was the cuſtom always to make ſuch holes in the balloons; which might eaſily be done by a pointed inſtrument, while the glaſs is ſtill hot and ſoft. Inſtead of this practice, chemiſts are themſelves obliged to drill holes through the balloons with conſiderable difficulty and hazard of breaking. This operation is performed in the following manner.

The moſt convenient part for drilling this hole is nearer the neck than the bottom of the balloon, and for this purpoſe one of thoſe bubbles which are always found in glaſs is choſen.

This bubble is firſt of all cut or broke by the pointed angle of a flint, and afterwards the hole is to be completed by turning this pointed flint always in the ſame place. Mr. Beaumé obſerves, that when an entry is once made by the flint, the hole may be better finiſhed by a triangular drill with a ſtrong hard tempered ſteel point, becauſe the angular points of the flint are continually breaking, by which the operation is prolonged. (*m*)

For certain operations balloons with two necks placed oppoſite to each other are uſed. One of theſe ought to be large enough to receive the neck of the retort, and the other to enter the neck of a ſecond balloon. Theſe two joinings muſt be well luted together. *See* LUTE.

This apparatus is called *Enfiladed Balloons*. Their uſe is to encreaſe the whole ſpace of the receiver, becauſe any number [illegible] be adjuſted to each other; and as they communicate with each other, [illegible] capacity is ſo much larger as their number is greater. But good artiſts ſeldom uſe ſo troubleſome an apparatus. The only one of theſe veſſels which is generally uſed, is a ſmall oblong balloon with two necks, which is to be luted to the retort and to the great balloon. It ſerves to remove this receiver from the body of the furnace, and to hinder it from being expoſed to too great heat. This ſmall balloon with two necks is called an *Adopter*. As this adopter is larger in its middle than at either extremity, it ſerves alſo to receive ſolid bodies, and to prevent them from paſſing with the liquids into the great balloon. It is chiefly in diſtillations of volatile concrete ſalts that the adopter ſerves for this laſt purpoſe. *See* DISTILLATION and RECEIVER.

(*m*) Such pierced balloons, receivers and retorts are commonly made in Engliſh glaſs-houſes. But as chemiſts may have occaſion to drill holes through glaſs veſſels, we ſhall [illegible], that this operation may be beſt per[illegible] with a copper drill and emery, as a [illegible] inſtrument occaſions vibrations apt to break the glaſs.

XCI. BALSAM. By balſams are meant oily, odoriferous, and aromatic matters, liquid, but ſomewhat thick, which flow ſpontaneouſly from certain trees, or from inciſions made on purpoſe to obtain a larger quantity.

Theſe balſams, which may more particularly be called *natural balſams*, to diſtinguiſh them from ſome compoſitions alſo called balſams, derive their liquidity and ſmell from a greater or leſs quantity of eſſential oil which they contain, and which may be extracted by diſtillation with the heat of boiling water. *See* OILS (ESSENTIAL).

Balſams may be even conſidered as true eſſential oils, which have loſt ſome of their odoriferous principle, and of their fineſt and moſt volatile part. When they are deprived of their remaining part of volatile oil, their reſiduums exactly reſemble thoſe which remain after the rectification of eſſential oils. Theſe reſiduums are true reſins, from the analyſis of which the ſame principles are obtained as from natural reſins; and theſe laſt are nothing but balſams exhauſted by time, or by the action of the air, and of the ſun, of all their odoriferous and volatile parts.

There are ſeveral kinds of natural balſams. They do not eſſentially differ from each other, but only in the ſmell and degrees of conſiſtence. The ſame kind of balſam alſo frequently differs with reſpect to the degrees of theſe two qualities.

The principal natural balſams are the *balſam of Mecca*, or the *white balſam*, which is the moſt rare and dear of all; the *balſams of Tolu* and of *Peru in ſhells*, both which Mr. Beaumé conſiders as the ſame kind of balſam, with this difference, that the firſt is liquid, and the ſecond is almoſt dry; the *balſam of Copahu*, or of *Copaiba*, vulgarly *Capivi*; *liquid ſtyrax*, or *ſtorax*; and *turpentines*. *See for an example of the analyſis and properties of all theſe balſams the word* TURPENTINE.

XCII. BALSAM *of* SULPHUR. The balſam of ſulphur is a ſolution of ſulphur in oil.

Sulphur, from the quantity of phlogiſton it contains, is inſoluble in water and aqueous liquors: but it is [illegible] of diſſolving in oils, which alſo contain much phlogiſton.

All oils, either expreſſed or eſſential, can diſſolve ſulphur: to make this ſolution, the oil ought to be poured on the ſulphur in a matraſs placed in a ſand-bath, and ſufficient heat applied to melt the ſulphur, according to Mr. Beaumé's obſervation, who kept theſe two ſubſtances a very long time together in a leſs heat, without perceiving any ſign of ſolution.

While the oil is diſſolving the ſulphur, it acquires a reddiſh or brown color, an acrid and diſagreeable taſte, and a ſtrong fetid ſmell like that of the combination of oil with vitriolic acid.

As water can diſſolve only a determinate quantity of ſome ſalts, and as this quantity is greater when the water is warm than when cold, ſo alſo oils can diſſolve only a determinate quantity of ſulphur, and this quantity is greater when heat is applied: hence it happens, that when an oil is ſaturated with ſulphur, by a ſuitable heat; a part of the ſu[illegible]as diſſolved ſeparates from the oil, when the ſolution cools, and coagulates [illegible] the bottom of the veſſel in a cryſtallized form, in the ſame manner as ſome ſalts do, which having been diſſolved in boiling water, cryſtallize on the application of cold.

The portion of ſulphur remaining diſſolved in oil is in a ſingular ſtate; the adheſion of its conſtituent parts, namely, the vitriolic acid and phlogiſton, ſeems to be much diminiſhed by the union they contract with the principles of the oil. Its vitriolic acid unites with the watery part of this oil; and thus theſe two principles have no longer the neceſſary relation to each other for the formation of ſulphur. *See* SULPHUR.

It is certain at leaſt, that all theſe changes happen when the balſam of ſulphur is diſtilled. This is proved by the analyſis which Homberg made of this combination: for by diſtilling it with a very ſlow fire, he obtained a volatile ſulphureous acid, a vitriolic acid more or leſs ſtrong and ſulphureous, ſome oil, partly fluid and partly thick, and a charry reſiduum, but no ſulphur. This is a proof that the ſulphur was decompoſed in the experiment; as all the ſame products are obtained from a combination of vitriolic acid with oil, when the oil is in too great quantity relatively to the acid.

The balſams of ſulphur are named from the particular oils which enter into their compoſition. Thus if a balſam of ſulphur be made with the eſſential oil of turpentine, it is called *terebinthinated balſam of ſulphur*; if it be made with the eſſential oil of aniſeed, it is called the *balſam of ſulphur with oil of aniſeed*. Theſe are the two moſt uſed. The balſam of ſulphur made with oil of nuts is called *Rulland's balſam of ſulphur*. *See* SULPHUR.

XCIII. BASALTES (n).

XCIV. BASIS *or* BASE. Any body which is diſſolved by another body, which it receives and fixes, and with which it forms a compound, may be called the baſis of that compound. Thus, for example, the baſes of neutral ſalts are the alkaline, earthy, and metallic matters which are ſaturated by the ſeveral acids, and form with them theſe neutral ſalts. In this ſenſe it is that theſe neutral ſalts are called *ſalts with earthy baſes, ſalts with alkaline baſes, ſalts with metallic baſes*; alſo the appellations, *baſis of alum, baſis of nitre, baſis of Glauber's ſalt, baſis of vitriol*, &c. ſignify the *argillaceous earth*, which, with the vitriolic acid, forms alum; the *vegetable alkali*, which with the nitrous acid, forms nitre; the *mineral alkali*, which, with the vitriolic acid, forms Glauber's ſalt; and the *metal*, which, with the vitriolic acid, forms a vitriol: becauſe theſe ſubſtances are ſuppoſed to be fixed, unactive, and only yielding to the action of the acids, which they fix, and to which they give a body and conſiſtence.

It is proper, for the convenience of chemical language, to retain theſe expreſſions: but theſe baſes muſt not be conſidered as really unactive; for in every combination and ſolution the ſeveral bodies which unite are equally active, their action being reciprocal. They diſſolve each other; ſo that it is as proper to ſay, as Mr. Gellert obſerves, that a metal or an earth diſſolves an acid, as that an acid diſſolves a metal or an earth; although this latter mode of expreſſion be more general. It is even probable that the diſſolving power which the more weighty and fixed bodies have is really much ſtronger than that of bodies leſs weighty and fixed. This is certainly ſo if the tendency to unite be only an effect of the general attraction or gravitation of all particles of matter to each other. *See* COMBINATION and SOLUTION.

(n) BASALTES is a heavy, hard ſtone, chiefly black or green, conſiſting of priſmatic cryſtals, the number of the ſides of which is uncertain. It is called by Engliſh authors *cockle*, and by Germans *ſchoerl*. Its ſpecific gravity is to that of water, as 3000 or upwards to 1000. It is conſidered by Wallerius as a ſpecies of the *corneus* or *horn-rock*. Cronſtedt enumerates it among the earths which he called *Garnet earths*. Baſaltes frequently contains iron, and conſiſts either of particles of an indeterminate figure, or of a ſparry, ſtriated, or fibrous texture. Black baſaltes is called *Lapis Lydius*, and is uſed as a touchſtone, to ſhew the colors of metals. Baſaltes has a flinty hardneſs, is unſoluble by acids, and is fuſible by fire. *See* GARNET.

XCV. **BATH.** Chemiſts call ſeveral matters which they employ to tranſmit heat, *Baths.* The matters moſt frequently uſed for this purpoſe are water and ſand.

When water is employed it is called *Balneum Mariæ*, or *water-bath.* The water-bath is much uſed, and is convenient for many operations.

As water, when expoſed to fire in any veſſel from which it can evaporate, does only receive a determinate degree of heat, which always remains the ſame, when once it has arrived to the boiling heat, it follows, that by the water-bath a degree of heat always equal may with certainty be tranſmitted. Further, this degree of heat being incapable of burning, or of communicating an empyreumatic quality to matters ſuſceptible of it, the water-bath has alſo the advantage of not expoſing ſubſtances to this inconvenience. The water-bath may likewiſe be employed ſucceſsfully for all degrees of heat inferior to that of boiling water. *See* ALEMBIC, *for the ſtructure of the water-bath.*

When veſſels in which diſtillations and digeſtions are made, are placed in ſand, then a *ſand-bath* is formed. This intermediate ſubſtance is alſo very convenient to moderate the too great activity of the naked fire, and to tranſmit any degree of heat from the weakeſt to a red heat. As this bath is attended with leſs trouble, and requires leſs apparatus than the water-bath, it is much uſed in laboratories. For the ſand-bath nothing is requiſite but an earthen or iron veſſel filled with fine ſand. This veſſel is fitted in to a furnace, and is capable of containing the cucurbits, retorts, matraſſes, or other veſſels containing the matter to be operated upon.

The only baths now generally uſed in chemiſtry are thoſe mentioned, the water and ſand-baths, becauſe they are the moſt convenient, and are ſufficient for all the operations which do not require a naked fire.

Ancient chemiſts, who had all a tincture, more or leſs, of alchemy, and who for that reaſon were much more careful and laborious in their operations, uſed many different baths, in order to apply preciſely the required degree of heat. They uſed the vapor of water, aſhes, dung, the ſubſtance remaining after the ſqueezing of grapes, and whatever they imagined moſt proper for their purpoſes: hence the names of *vapor-bath*, *aſh-bath*, *dung-bath*, *bath of a horſe's belly*, &c. But as we have ſaid, an intelligent and experienced artiſt may very well perform all the chemical operations, which do not require a naked fire, by means of the water and ſand-baths. *See* DISTILLATION *and* DIGESTION.

The word *bath* is alſo uſed in another ſenſe to ſignify the fuſion of metallic matters in certain operations: thus, for example, in refining or cupelling, the metals are ſaid to be *in bath*, when they are melted. When gold is purified by antimony, this ſemimetal melted is called by ſome chemiſts the *bath of gold.* Alchemiſts, who conſider gold as the king of metals, call antimony, *the bath of the king only*, *balneum ſolius regis*; becauſe, in fact, gold only can reſiſt the action of antimony. *See* PURIFICATION *of* GOLD *by* ANTIMONY.

XCVI. BDELLIUM. (o)

XCVII. BEE-GLUE. (p)

XCVIII. BEER. Beer is a ſpirituous liquor made from any farinaceous grain, but generally from barley. It is, properly ſpeaking, the wine of barley. The meals of any of theſe grains being extracted by a ſufficient quantity of water, and remaining at reſt in a degree of heat requiſite for the ſpirituous fermentation, naturally undergo this fermentation, and are changed into a vinous liquor. But as all theſe matters render the water mucilaginous, fermentation proceeds ſlowly and imperfectly in theſe liquors. On the other ſide, if the quantity of farinaceous matter be ſo diminiſhed that its extract or decoction may have a convenient degree of fluidity, this liquor will be impregnated with ſo ſmall a quantity of fermentable matter, that the beer or wine of the grain will be too weak, and have too little taſte.

Theſe inconveniences are remedied by preliminary operations which the grain is made to undergo.

Theſe preparations conſiſt in ſteeping it in cold water that it may ſoak and ſwell to a certain degree, and in laying it in a heap with a ſuitable degree of heat, by means of which, and of the imbibed moiſture, a germination begins, which is to be ſtopped by a quick drying, as ſoon as the bud ſhews itſelf. To accelerate this drying, and render it more compleat, the grain is ſlightly roaſted, by making it paſs down an inclined canal ſufficiently heated.

This germination, and this ſlight roaſting, changes conſiderably the nature of the mucilaginous fermentable matter of the grain. The germination attenuates much, and in ſome meaſure totally deſtroys the viſcoſity of the mucilage; and it does this, when not carried too far, without depriving the grain of any of its diſpoſition to ferment. On the contrary, it changes the grain into a saccharine ſubſtance, as may be perceived by maſhing grains beginning to germinate. The ſlight roaſting contributes alſo to attenuate the mucilaginous fermentable matter of the grain. When the grain is thus prepared, it is fit to be ground, and to impregnate water with much of its ſubſtance without forming a glue, or viſcous maſs. The grain thus prepared is called *malt*. This malt is then to be ground, and all its ſubſtance, which is fermentable and ſoluble in water, is to be extricated by means of hot water. This extract or infuſion is ſufficiently evaporated by boiling in caldrons; and ſome plant of an agreeable bitterneſs, ſuch as hops, is at that time added, to heighten the taſte of the beer, and to render it capable of being longer preſerved. Laſtly, this liquor is put into caſks, and allowed to ferment; nature performs the reſt of the work, and is only to be aſſiſted by the other moſt favorable circumſtances for the ſpirituous fermentation. See FERMENTATION (SPIRITUOUS).

XCIX. BEN. (q)

(o) BDELLIUM is a gum reſin, from an ounce of which may be extracted by water ſix drams and two ſcruples, or by ſpirit two drams. *Neuman.*

(p) BEE-GLUE is a ſoft, unctuous, glutinous matter employed by bees to cement the combs to the hives, and to cloſe up the cells. *Neuman.*

(q) BEN-NUTS yield, by expreſſion, much oil, which, from its property of not becoming rancid, at leaſt for years, is uſed as a menſtruum for the extraction of the odoriferous part of flowers of jaſmin, violets, roſes, hyacinths, lillies of the valley, tuberoſes, jonquils, clove-july flowers, and others, which, like theſe, yield little or no

C. BENJAMIN. *Benjamin*, or *Benzoin*, is a reſin of an agreeable aromatic ſmell, from which an eſſential ſalt, or volatile, concrete, cryſtallized acid, called *flowers of Benjamin*, is obtained by ſublimation. *See* FLOWERS *of* BENJAMIN. As to its other principles, it is ſimilar to other reſins. *See* RESIN.

CI. BERYL. (r)

CII. BEZOAR MINERAL. Bezoar mineral is the earth of the regulus of antimony deprived of all its phlogiſton by the action of the nitrous acid and by calcination.

The ordinary proceſs to make this preparation conſiſts in diſſolving butter of antimony in a ſufficient quantity of nitrous acid, or till the phenomena of ſolution ceaſe. If more nitrous acid be added than is neceſſary for the ſolution, no inconvenience follows, as we ſhall preſently ſee.

When the ſolution of butter of antimony is made, it is to be evaporated to dryneſs in a glaſs or ſtone-ware veſſel: more nitrous acid is then to be poured upon it; rather too much than too little; becauſe an exceſs of this does no harm: this ſolution is to be evaporated, as at firſt; and the ſame operation is to be repeated a third time; after which the matter being dryed, is to be calcined for half an hour, till, according to Lemery, a very ſlight acidity only remains.

This operation, which was invented for the preparation of a remedy, furniſhes phenomena very worthy of attention, and fit to illuſtrate the eſſential properties of the nitrous and marine acids. The following remarks then are to be made on this ſubject: Aqua-regia being the moſt active menſtruum of regulus of antimony; and ſpirit of nitre, in which the butter of antimony is diſſolved, forming an aqua-regia with the marine acid contained in this butter; a new ſolution is made of the reguline part, which after this is no longer united with the marine acid only, but with the nitrous and marine acids jointly, that is, with aqua-regia. When this ſolution is not hurried too much, it is clear and limpid; and this is the beſt method of having the greateſt poſſible quantity of regulus of antimony perfectly diſſolved by aqua-regia.

As upon this occaſion, the nitrous [illegible] finds the integrant parts of the regulus of antimony ſeparated from each other by the interpoſition of the parts of the marine acid, and conſequently the aggregation of the regulus of antimony broken, this nitrous acid ſeizes upon all the parts of the regulus with ſo much more facility and almoſt inſtantaneouſly: hence it happens that unleſs the nitrous acid be gradually added, and at long intervals, the ſolution is made ſo impetuouſly, that all the matter is apt to riſe inſtantly over the containing veſſel with efferveſcence, which happens in moſt ſolutions, and which proceeds from diſengaged air. The

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eſſential oil by diſtillation, but impart their fragrance to expreſſed oils. The method of impregnating oil of ben with the odor of flowers is this: Some fine carded cotton is dipt in the oil, and put in the bottom of a proper veſſel. On this is ſpread a thick layer of freſh flowers, above which more cotton dipt in oil is placed; and thus alternately flowers and cotton are diſpoſed, till the veſſel (which may be made of tin, with a cover to be ſcrewed on to it, or of porcelain) is full. By digeſtion during 24 hours in a water-bath, the oil will receive the odor of the flowers.

(r) BERYL, or AQUA-MARINA, is a polygonous pellucid gem, the tenth from a diamond in hardneſs, of a ſea green color, and fuſible by fire. This gem may be imitated by adding, at ſeveral different times, to twenty pounds of cryſtal-glaſs, made without magneſia, and well purified from glaſs-gall, ſix ounces of calcined braſs or copper, and a quarter of an ounce of prepared zaffre.

quantity of air in this ſolution is very great. Dr. Hales has aſcertained that thirty-ſix cubic inches of air are diſengaged from the ſolution of half a cubic inch of butter of antimony in as much nitrous acid: but this muſt vary according to the manner of making the ſolution. Is it even certain that it is air which is thus diſengaged, and not ſome other ſubſtance reduced to elaſtic vapor?

However it be, the new combination of regulus of antimony with the acids of aqua-regia is very different from the butter of antimony. The preſence of the nitrous acid produces an entire change. This metallic ſubſtance is no longer united with a ſingle acid, incapable of depriving it of its phlogiſton, and which, by its intimate union, communicates to the ſemimetal its volatility. The nitrous acid cannot unite with the regulus of antimony without depriving it of a large portion of its inflammable principle. The regulus thus half calcined can no longer have the ſame adheſion to the marine acid; therefore if this new combination be expoſed to the action of fire, the marine acid, which now ſcarcely adheres to this altered metallic matter, far from raiſing it, as when it was combined with no other acid, does with great facility evaporate; and the nitrous acid, which adheres ſtill leſs than the marine acid to this metallic earth, quits it ſtill more eaſily, and continues to deprive it more and more of its inflammable principle.

The ſame effects ought to take place ſtill more upon the new additions and evaporations of the nitrous acid; therefore, after all theſe operations, nothing remains but an earthy white matter, abſolutely fixed, unfuſible, and inſoluble in acids, which has no longer any emetic or purgative qualities, nor any taſte, if ſufficiently calcined. It is, in ſhort, a true calx of antimony, entirely ſimilar to diaphoretic antimony, except that to this latter preparation a ſmall portion of the earth of the alkaline baſis of nitre adheres, which is not to be found in bezoar mineral: hence we ought to conclude, that nitrous acid produces the ſame effects upon the regulus of antimony by the humid, as it does by the dry way.

When bezoar mineral is prepared for the purpoſes of medicine, it is proper not to calcine it too much; otherwiſe it would probably have no virtue. When it is moderately calcined, as Lemery preſcribes, it may have the ſudorific virtue aſcribed to it, from the ſmall quantity of acid and perhaps of phlogiſton adhering to it. It is this ſudorific virtue, truly or falſely aſcribed, which has occaſioned the name of bezoar mineral, becauſe the animal bezoar is conſidered alſo as a ſudorific.

It is evident from what has been ſaid concerning the nature of the bezoar mineral, and what paſſes during its preparation, that the marine acid contained in the butter of antimony is entirely loſt, and not eſſential to the operation, ſince the nitrous acid alone is capable of depriving the regulus of antimony of all its phlogiſton, and of reducing it to a white calx entirely ſimilar to bezoar mineral. Inſtead then of employing butter of antimony, which requires a preliminary and expenſive preparation, the nitrous acid may be directly poured upon the powdered regulus, and its action aſſiſted by heat. This acid readily corrodes the ſemimetal, without diſſolving it; becauſe it deprives it of its phlogiſton while it attacks it, and quickly reduces it to a white calx.

When this acid is carried off, and more acid poured on, and this repeated ſeveral times, till the matter is at laſt calcined, a white calx of antimony is obtained entirely ſimilar to bezoar mineral.

CIII. BILE. (s)

CIV. BISMUTH. Biſmuth, called alſo *tin-glaſs*, and by ſome naturaliſts *marcaſita officinarum*, is a ſemimetal ſomewhat ſimilar to the regulus of antimony. It appears to be compoſed of cubes formed by the application of plates upon each other. Its color is leſs white than that of the regulus of antimony, and has a reddiſh tinge, particularly when it has been expoſed to the air.

It is the heavieſt of the ſemimetals, and loſes in water about a ninth part of its weight.

It is alſo very fuſible, and melts a long time before it is red-hot.

Biſmuth is ſemi-volatile, like the other ſemimetals. When expoſed to the fire, flowers riſe from it; it is calcined; and converted into a litharge and glaſs nearly as lead is. It may even be employed, like that metal, to the purification of gold and ſilver by cupellation.

It eaſily combines with ſulphur, and is thereby reduced into a ſtriated mineral like antimony.

It amalgamates with mercury, and, according to Mr. Wallerius, it has the ſingular property of ſo attenuating tin, ſilver, and eſpecially lead, when any of theſe metals are added to this amalgam, that a part of them paſſes along with the mercury through chamois leather. This ſufficiently proves that this method of purifying mercury is inſufficient. *(Wallerius's Mineralogy).*

Mr. Cramer, on the contrary, ſays that only lead, and not the other metals, can be ſo diſpoſed by biſmuth as to paſs along with the mercury. He adds, that the lead muſt be previouſly united by fuſion with the biſmuth; and that if the amalgam be digeſted during ſome days, the biſmuth is ſeparated, and the lead is left attenuated with the mercury.

This ſemimetal is not equally ſoluble in the ſeveral acids.

The vitriolic acid does not, properly ſpeaking, diſſolve biſmuth. If a part and a half of biſmuth be mixed with one part of concentrated vitriolic acid, the whole diſtilled to dryneſs, and the reſiduum waſhed with water, the liquor drawn off is of a red yellow color, but from which nothing can be precipitated by alkalis: hence it may be ſuſpected that the vitriolic acid attacks only the inflammable part of biſmuth, and does not diſſolve its metallic earth.

The nitrous acid diſſolves biſmuth very well.

The marine acid attacks and diſſolves biſmuth a little, but ſlowly and difficultly. Alkalis form a precipitate with marine acid in which biſmuth has been digeſted a certain time.

This ſemimetal does not very ſenſibly detonate with nitre. It is, nevertheleſs, calcined by this ſalt, as all the imperfect metals and ſemimetals are.

Two parts of nitrous acid diſſolve with heat and efferveſcence one part of biſmuth. The ſolution is clear, limpid, and roſe-colored. It coagulates into ſmall cryſtals as ſoon as it cools.

(s) **Bile** *of* **Animals** is an oily, viſcid, ſaponaceous fluid, diffuſible in water, and when thus diluted, more putreſcent than other animal fluids. Inſpiſſated bile may, by heat, be firſt melted, and then decompoſed, yielding by diſtillation an urinous ſpirit, a volatil ſalt, much empyreumatic oil, and a reſiduum containing a conſiderable quantity of fixed alkali. Acids alſo decompoſe it, are thereby neutralized, and precipitate from it a reſinous matter, not ſoluble in water, but partly ſoluble in ſpirit of wine.

This ſolution ought to be made gradually, to avoid too great commotion and efferveſcence.

Water alone being added to this ſolution, precipitates the biſmuth. The precipitate is of a very beautiful white, and is commonly called *magiſtery of biſmuth*, and by ſome artiſts *Spaniſh white*, being the ſame which is uſed as a paint for the ſkin.

To have this white very beautiful, an aqua-fortis muſt not be employed, which is adulterated by a mixture of vitriolic acid; for this latter acid gives it a greyiſh caſt.

If the nitrous acid has diſſolved but little biſmuth, much more water is ſary to effect a precipitation.

This magiſtery ought to be well waſhed, to deprive it as much as poſſible of the adhering acid, and preſerved in a well cloſed bottle; becauſe this ſemimetal, when thus divided, has, like ſilver and lead, the property of eaſily combining with phlogiſton in vapor, and of becoming black by that addition: hence the ſkin of women painted with this white may be rendered quite black by the phlogiſtic vapors which riſe from putrefying matters, neceſſary-houſes, ſulphur, liver of ſulphur, bruiſed garlic, &c.

Alkalis alſo added to the ſolution of biſmuth occaſion a white precipitate of this ſemimetal, but not ſo beautiful as when water only is uſed; becauſe the pureſt alkalis contain ſome phlogiſton, which gives more or leſs color to the precipitate.

Some authors recommend a ſolution of ſea-ſalt in water for the making of this precipitate. But Mr. Pott, in his Diſſertation on Biſmuth, has ſhewn that the marine acid does not precipitate this ſemimetal, and ſeparate it from the nitrous acid, as it does ſilver, lead, and mercury.

Thus, although biſmuth reſembles lead in many of its properties, as the younger Mr. Geoffroy has ſhewn in the Memoirs of the Academy, ſo that ſome chemiſts have called it the lead of the ſemimetals, it appears, that, beſides want of ductility, it differs eſſentially from that metal in other reſpects.

Lemeri ſays, that if the ſolution of biſmuth be uſed to write with as an ink, that the writing does not appear, but that it becomes very black, when moiſtened with the deliquiated liquor of the ſcoria of regulus of antimony. This ſolution is therefore a ſympathetic ink. The reaſon of this phenomenon is founded on what we have obſerved concerning the property which biſmuth has, when much divided, of eaſily imbibing a ſuperabundant quantity of phlogiſton, and by that means of acquiring a black color.

The ſcoria of regulus of antimony is almoſt entirely liver of ſulphur. The alkali of this liver precipitates the biſmuth from the ſolution employed to write with; and the ſulphur or phlogiſton, diſengaged from the liver, blackens the biſmuth, which therefore becomes viſible.

It is evident after this explanation, that it is needleſs to have recourſe to the ſolution of ſcoria of regulus of antimony in this experiment; for it only acts as a liver of ſulphur; and the portion of regulus of antimony contained in this ſcoria contributes nothing to the ſucceſs: the liver of ſulphur alone may therefore be as well employed.

Biſmuth readily unites with all metallic matters, excepting, according to Mr. Gellert, zinc and arſenic; and all the allays are rendered more fuſible by biſmuth. This chemiſt places the affinities of metallic matters with biſmuth in the following order: iron, copper, tin, lead, ſilver, and gold. (t)

CV. **BISTRE.** (u)

CVI. **BITTERN.** (w)

CVII. **BITUMEN.** Bitumens are oily matters, of a ſtrong ſmell, and of different conſiſtences, which are found in many places within the earth.

There is only one liquid bitumen known: it is called *petroleum*, becauſe it is an oil which actually flows from clefts in certain rocks, and it is gathered in wells dug in certain grounds and mountains. *See* PETROLEUM.

Solid bitumens are *Amber*, called alſo *Karubé*, or *yellow amber*; *Jet*; *Aſphaltum*, or *bitumen of Judea*; and foſſil or *pit-coal*.

All theſe bitumens, when diſtilled, furniſh phlegm, an acid liquor frequently ſulphureous, a thin oil like petroleum, a volatile acid and concrete ſalt, (of which amber gives the largeſt quantity) a black and thick oil, and laſtly, a charry reſiduum, more or leſs earthy and copious, according to the nature of the particular bitumen analyſed. Foſſil coal furniſhes the largeſt quantity of this reſiduum. From this analyſis it appears, that bitumens are compoſed, like all other vegetable and animal concrete oily matters, of an oil and an acid. They differ in general from reſins by their greater ſolidity; by their ſmell, which is ſtronger, and not like the aromatic ſmell of reſins; by their inſolubility in ſpirit of wine; by the volatile ſulphureous acid; and finally, by the concrete acid obtained in their analyſis.

The origin of bitumens is an intereſting queſtion, concerning which naturaliſts are not agreed; ſome imagining that they eſſentially belong to the mineral kingdom, and others that they proceed originally from vegetable ſubſtances. We

(t) 1. Biſmuth, like iron, is ſaid to *occupy, when fuſed, a leſs ſpace than when ſolid.* 2. It is *fuſible* with a heat of 460° of Fahrenheit's thermometer. 3. It greatly *encreaſes the fuſibility of ſome other metals.* Thus, an allay conſiſting of equal parts of tin and biſmuth is fuſible with a heat of 280° of Fahrenheit's ſcale. 4. Equal parts of *gold* and *biſmuth* form a brittle regulus colored like biſmuth. Equal parts of *biſmuth* and *ſilver* form a maſs not ſo brittle as the former. A ſmall portion of biſmuth encreaſes the brightneſs, hardneſs, and ſonorouſneſs of *tin*. The color of *copper* is rendered leſs red, but not white, by biſmuth. Equal parts of *biſmuth* and *lead* form a dark grey compound. Biſmuth may be united with *iron* by a ſtrong heat. It does not unite with *zinc* or with *regulus of cobalt*, or only in a ſmall proportion. 5. The *uſes* of biſmuth are, for making *pewter* with tin; for *ſoldering* ſome metals; for *printers types* (Homberg adviſes one part of biſmuth and one of tin to be added to twelve parts of the common compoſition, which is one part of copper, one part of regulus of antimony, and five parts of lead); for *foils for mirrors*, the common mixture for this being one part of tin, one part of lead, two parts of biſmuth, and ten parts of mercury; for *anatomical injections*, equal parts of lead, tin, and biſmuth, to which ſome add a little mercury, forming a mixture ſufficiently fuſible; for *imitating ſilvering on wood*, for which purpoſe it is ground, applied with whites of eggs, and burniſhed; for *purifying gold and ſilver by cupellation*, for which it is preferable to lead, as it more effectually deſtroys imperfect metals, promotes the vitrification of earths and calxes, and combines with ſulphur, forming a very fuſible maſs; and laſtly, for *rendering ſome metals fitter for being caſt into moulds*, as a ſmall portion of it encreaſes their fuſibility.

(u) BISTRE is a brown pigment, conſiſting of the finer parts of wo[illegible] by water from the groſſer.

(w) BITTERN is the bitter ſaline liquor which remains after the cryſtallization of ſea-ſalt in ſea-water, or the water of ſalt ſprings. *See* WATER (SEA).

muſt allow this latter opinion to be the moſt probable: for, firſt, no body the origin of which is certainly mineral, contains the ſmalleſt portion of oil. Even ſulphur, which of all minerals approaches moſt to the nature of bitumens, and which all the ancient chemiſts have conſidered as ſuch, does not contain, as Stahl has demonſtrated, the ſmalleſt veſtige of oil.

2dly, It is probable that the qualities by which bitumens differ from reſins and other oily matters, vegetable and animal, are either the natural effects of time upon theſe oily matters converted into bitumens, or of an alteration produced upon them by mineral acids; or rather they are the effect of both theſe cauſes united.

Thirdly, by combining mineral acids with vegetable oils, compounds may be formed much reſembling natural bitumens, and to which perhaps nothing but a ſufficiently long digeſtion is wanting to render them true bitumens.

Fourthly, we cannot doubt that the vegetable and animal matters continually deſtroyed on the ſurface of the earth, the juices of which are capable of penetrating further, muſt introduce into the earth much oily matter, which, in time, may become bitumen.

Beſides, natural hiſtory proves, that many entire vegetables and animals have been buried in large quantities, and even at conſiderable depths, by the various accidents and revolutions which have happened upon the earth; for under ground immenſe beds of turf are daily found, and large banks of half-decompoſed, bituminous, and petrified foſſil wood, which can be nothing elſe but conſiderable portions of the ſurface of the earth, thus buried by accidents too ancient to be remembered. All theſe matters are ſufficient to furniſh the earth with a large quantity of truly oily ſubſtance, which probably can be formed only in the organiſed bodies of vegetables and animals.

Junker deſcribes, after Neuman, the Pruſſian amber mines, which are the richeſt known. Firſt, at the ſurface of the earth is found a ſtratum of ſand. Immediately under this ſand is a bed of clay filled with ſmall flints of about an inch diameter each: under this clay lies a ſtratum of black earth or turf, filled with foſſil wood, half-decompoſed and bituminous: this ſtratum is extended upon a bank of minerals containing little metal, excepting iron, which are conſequently pyrites: laſtly, under this bed the amber is found ſcattered about in pieces, or ſometimes accumulated in heaps.

If we add to all this, that in amber are frequently included inſects and fragments of plants, we ſhall find a further probability that bitumens are of vegetable original.

It is true that amber, petroleum, and other bitumens are found in grounds where no foſſil vegetable matters exiſt; but it is eaſy to conceive that theſe matters may have been deſtroyed, and their appearance changed by time, particularly as the different natures of ſoils contribute much to the preſervation or deſtruction of vegetable and animal ſubſtances.

Thoſe bitumens which are ſufficiently compact to be cut and poliſhed, ſuch as amber and jet, are formed into toys and ornaments, as necklaces, heads for canes, buttons, and mourning ear-rings.

Bitumens are alſo uſed for the preparation of very ſolid and beautiful oil varniſhes. For this purpoſe amber is chiefly uſed. *See* Amber *and* Varnish. (*x*)

CVIII. BLACKNESS. (*y*)

(*x*) Notwithſtanding the reference made in the text to *amber* and *varniſh*, both theſe articles are omitted by the author: we ſhall therefore make ſome addition concerning *amber varniſhes.*

A *fine black varniſh* may eaſily be made by diſſolving amber previouſly melted in a crucible till it is rendered black, in boiling linſeed oil. But the ſolution of amber without decompoſition, by which its color is altered, in linſeed or other expreſſed oils, is more difficult, and has been unſucceſsfully attempted by Neuman and other chemiſts. Hoffman ſays, that he reduced amber and oil of olives to a gelatinous maſs by placing the glaſs-veſſel containing them in Papin's Digeſtor, one third part of which was full of water. The experiments of Dr. Stockars are more deciſive. He ſays, that, by continuing a ſimmering heat during twelve hours, and by confining the vapors as much as ſtone-ware veſſels would bear, powdered amber was perfectly diſſolved in expreſſed oils, in turpentine, and in balſam of copaiba. He prevented the veſſels from burſting, by making ſmall notches in the corks with which he ſtopped them. The ſolutions of amber in oils of rape-ſeed and of almonds had a fine yellow color; in oil of linſeed a golden color; in oil of poppy a yellowiſh red; in oil of olives a beautiful red; in oil of nuts a deeper red; in oil of bays a purpliſh red. Solutions of amber in turpentine and balſam of copaiba had a deep red color, and when cooled, formed hard brittle red maſſes. All theſe ſolutions were eaſily miſcible with ſpirit of turpentine. Thoſe made with oils of linſeed, bays, poppies, and nuts, with balſam of copaiba, and with turpentine, being diluted with four times their quantity of ſpirit of turpentine, formed hard, tenacious, gloſſy varniſhes, which dried ſufficiently quick. See *Dr. Stockars's Specimen Inaugurale de Succino, Leyden*, 1760.

Amber may be rendered clear and pellucid by two methods. 1. By cementing lumps of it with ſand, during 40 hours, in an iron pot. 2. By digeſting them during 20 hours in boiling rape-ſeed oil.

A *tincture* may be extracted from amber by rectified ſpirit of wine, or by ſweet ſpirit of vitriol.

From 16 oz. of coarſe amber Neuman obtained, *by diſtillation*, eleven ounces ſix drams of oil, four drams and a half of ſalt, (*ſee* Salt *of* Amber) one ounce and a half of water, and nearly one ounce of caput mortuum.

(*y*) Blackness. Dr. Lewis, in his *Philoſophical Commerce of Arts*, has written copiouſly concerning the ſubſtances capable of communicating blackneſs. What we ſhall ſay on this ſubject ſhall be chiefly extracted from that work.

"The *native black coloring materials* are, 1. *Black chalk*, or *black marking ſtone*, which ſeems to be a ſlaty bituminous ſubſtance, unſoluble by acids, and capable of being rendered friable and red by fire. It ſtains freely. When powdered, it does not loſe its blackneſs, and may then be formed with oil into a paſte, or with water into a ſlimy maſs; which properties render it uſeful to painters. 2. *Pitcoal* mixed with oil produces a browniſh black. 3. *Black ſand* found in Virginia, ſtrewed upon writing while yet wet, dries and gives luſtre to the ink. This ſubſtance might be uſed in oil painting to give a ſparkling black. What this ſubſtance is Dr. Lewis has not mentioned. I have eſſayed a black ſparkling powder uſually ſold for ſtrewing upon writing, and found it to conſiſt of minute particles of the lead-ore called *galena*. 4. *Black-lead*, the color of which is rather a deep ſhining blue than a black, is ſmooth and unctuous, and hence is uſed, as ſoap and oil are, to prevent the friction of machines. It is unſoluble by acids, and unfuſible by fire: in cloſe veſſels it is unalterable by fire; but by a long calcination in an open fire it is moſtly volatiliſed, emitting, according to Lawſon, (*Diſſertatio de Nihilo*) inflammable blue flowers, and the reſiduum is a yellow calx, which being reduced by Mr. Queſt, (*ſee Swediſh Acts*, 1754) ſeemed to be a mixture of iron and tin. Black lead may be readily mixed with melted ſulphur, and of this compoſition pencils are formed much inferior

CIX. BLACK-JACK. (z).

CX. BLOOD. Blood is well known to be a red liquor in moſt animals.

ferior to thoſe made of ſlips of entire black lead fitted into pieces of cedar wood. 5. *Black vegetable juices.* The excellent black varniſh of China and Japan is a native juice exſuding from inciſions made in certain trees, one of which is ſaid to be that, the fruit of which is brought to Europe, called *anacardium.* Anacardium contains a black juice which gives to linnen and cotton a reddiſh brown ſtain, which, by expoſure to air, becomes black, and is incapable of being diſcharged by waſhing or boiling with ſoap or alkaline leys. [illegible] oriental varniſh is ſaid by others to be produced from the tree called [illegible]. 6. *Cuttle-fiſh* contains in a certain veſſel, a fluid as black as ink, and which is ſaid to be fit for the ſame purpoſes.

The *black-coloring materials produced by fire* are, 1. *Coals,* which, entire or powdered, is often uſed [illegible]. For this purpoſe artiſts uſe the tender branches of trees, chiefly of the ſofter woods, as willows and vines, freed from the bark and pith. The coal of bones and other animal ſubſtances is gloſſier and deeper colored than vegetable coals: that of ivory is ſuperior to the reſt. 2. *Soots* are ſofter than coals, and more eaſily miſcible with oil or water. A part of wood ſoot is ſoluble in water. From an infuſion in wood ſoot in water is prepared the brown pigment called *Biſtre,* uſed for painting in water-colors. The fineſt of the ſoot blacks is *lamp-black,* uſually prepared by burning in an oven the dregs and pieces of pine-bark left in the proceſs for making common roſin. Soots prepared by burning ſmall pieces of wood or of mineral bitumen very ſlowly under a copper pan, were found by Dr. Lewis to be not different from thoſe prepared from oils and reſins; and, like theſe, contained nothing ſoluble in common water, as the ſoot collected in common chimneys does. *See* SOOT.

The *black-coloring materials produced by mixture* are, 1. A ſolution of green vitriol in water, added to an infuſion of galls or ſome vegetable aſtringent, is the baſis of black inks, and black dyes for the uſes of callico printers, tanners of leather, hatters, dyers, &c. The color given by this mixture adheres permanently to ſilk and wool, but may be diſcharged from linnen and cotton by waſhing. If the water employed for diſſolving the vitriol, or infuſing the galls, have been diſtilled, or is the common ſpring water, or freſh rain water, the color produced will be bluiſh; and if the water has any putrid or alkaline quality, the color produced will have a purpliſh or [illegible]. The blackneſs given by galls [illegible] improved by addition of [illegible]. [illegible] table aſtringents do not produce a blackneſs by mixture with ſolution of green vitriol. Thus the Peruvian bark is ſaid to give a greeniſh color. *See* INK. 2. A *ſolution of ſilver* in nitrous acid gives black ſtains to ſolid white animal ſubſtances, to agates, and ſome other ſtones, afterwards expoſed to the ſun and air. Bones and hair at firſt receive no ſtain, but ſooner or later, as they happen to be more or leſs expoſed to the ſun and air, they become of a reddiſh or purple color, which gradually changes to a brown, and afterwards to a black. Mr. Schulze (*Act. Natur. Curioſ. vol* I.) ſays, that white chalk moiſtened with ſolution of ſilver, on expoſure to the ſun, acquires a purpliſh black color on its ſurface, which [illegible] be interrupted by threads ſhading parts of the chalk. If the chalk, thus moiſtened with ſolution of ſilver, be dried in the ſhade or by fire, no color will be produced. No color was given by this method to white clay, talk, or plaſter of Paris. The action of ſolar light alſo gives a dark color to the white precipitate of biſmuth, and to ſweet mercury. 3. A black ſtain is given to paper or other white ſubſtances, by *ſolutions of [illegible] in acids,* when theſe ſubſtances are afterwards expoſed to phlogiſtic or ſulphureous vapors. *See* INK (SYMPATHETIC). 4. [illegible] *melted with ſulphur* form a blue or black [illegible] maſs uſeful for taking caſts from medals, and is leſs brittle than ſulphur alone. Mr. Le Blon found that a black color may be produced by mixing blue, red, and yellow pigments; and Mr. Cattel directs that fifteen parts of blue ſhould be mixed with five parts of red, and three of yellow, and that each of theſe colors ſhould be very deep. Dr. Lewis tried ſuch mixtures, but produced only a browniſh or greyiſh black.

(z) BLACK-JACK, or BLEND, is a mineral, called alſo *falſe galena.* *See* GALENA (FALSE).

circulating in their veſſels during life, and the common ſource whence all the neceſſary and ſuperfluous animal liquids are derived. *(a)*

Blood newly drawn from a ſound animal gives no ſign of an acid or alkaline quality. It has a ſweetiſh and ſomewhat ſaline taſte. When left to itſelf, it coagulates, and quickly paſſes to a fermentation at firſt a little acid, and afterwards entirely putrid, in the ſame manner as all other perfectly animaliſed ſubſtances.

This liquor contains nothing volatile by the heat of boiling water, but a pure phlegm. Thus when blood is diſtilled in a water-bath, it is only dried, not entirely decompoſed. By this drying it loſes $\frac{7}{8}$ of its weight. The reſiduum being diſtilled in a naked fire, yields volatile alkali, and animal oil, at firſt thin, and afterwards thick: in the retort a charry reſiduum remains, which can difficultly be reduced to aſhes, from the lixiviation of which a little common ſalt may be obtained.

From this analyſis, which is almoſt all that chemiſts have done to diſcover the nature of the blood, it appears that this liquor contains the ſame principles as all other perfectly animaliſed matters. But a more accurate examination might probably be made of it by ſeparating at firſt from each other ſeveral different ſubſtances, of which the blood is only a collection or mixture, and then by analyſing each of theſe ſubſtances, as has been done with milk.

In fact, the blood being opake, or not very tranſparent, appears to be, as milk is, nothing elſe than a mixture of ſeveral heterogeneous matters confounded together, without being diſſolved by each other. It is known, that, when the blood is no longer circulated in the veſſels of the animal, but left at reſt in a veſſel, it coagulates and ſeparates ſpontaneouſly into a red maſs, and a white liquor, or ſerum, in which the red maſs floats; and that by waſhing, the red part of this maſs may be carried off, and the remaining matter is white and gelatinous. There are then three diſtinct matters in the blood which ſeem to correſpond with thoſe contained in milk; that is, the ſerum of the blood correſponds with the whey of milk; the white gelatinous matter, with the cheeſy part; and laſtly, the red globules with the butyraceous ſubſtance.

It is ſo much more probable that the red part of the blood is oleaginous, as anatomiſts, who have examined the blood by microſcopes, have obſerved that this red part is compoſed of globules ſwimming in a white liquor, and as all oily matters, when well mixed, but not diſſolved in a watery fluid, have this globular appearance. *(b)*

This being eſtabliſhed, if the blood were to be examined more exactly than it has hitherto been, it would probably be neceſſary to begin by ſeparating from each other the three above-mentioned ſubſtances, each of which ought afterwards to be ſubjected to experiments and analyſes, as has been done with milk. It is probable that this method of analyſing blood would throw new light upon its

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(a) The color of blood, like that of many other ſubſtances, is affected by expoſure to air, by which it acquires a ſcarlet tinge. Arterial blood has this ſcarlet color, which it has acquired by paſſing through the lungs in reſpiration. The blood flowing through the veins has a deeper and leſs vivid red color. It acquires the ſcarlet color by expoſure to air, and arterial blood loſes its vivid red color by excluſion from air.

(b) The red particles of blood are ſaid to have an annular form.

nature and principles, which are yet very imperfectly underſtood, as well as thoſe of other animal matters.

The purely gelatinous parts of the blood are probably not different from any other animal jelly; but it is to be preſumed that ſome peculiar ſalts might be obtained from the ſerous parts, as have been from milk and from urine; and that the red globular part would be found to be oleaginous. The acid, or volatile alkaline principles which would be obtained from the red part of the blood would determine whether or not it is a truly animal oil, or fat. If it be true, as Mr. Homberg and Mr. Macquer affirm, that ſome acid may be obtained by analyſing the blood, it would probably be found to belong to this red ſubſtance.

Laſtly, it is evident that whatever knowledge could be acquired on this ſubject by well-conducted experiments, muſt extend and encreaſe an intereſting branch of our knowledge, namely, that concerning animal economy. (c)

CXI. BLUE. (d)

(c) Dr. Fordyce, in his very excellent Elements of the Practice of Phyſic, ſays, that the white gelatinous matter of the blood, or *coagulable lymph*, continues fluid while circulating with any degree of heat betwixt 30 and 120° of Fahrenheit's thermometer; but that it is coagulated very ſoon after it is taken out of the body in any heat, in motion, or in reſt; and that its coagulation may be prevented by ſaturating the blood with ſea-ſalt, or perhaps with ſome other neutral ſalts. The coagulum is rendered ſoluble in boiling water, by putrefaction, by concentrated acids, cauſtic alkalis, calcareous earths, and by ſome metallic ſalts. He obſerves alſo, that the coagulable lymph is more fluid, and is not ſo eaſily coagulable when the arteries of the perſon from whom the blood is drawn act more ſtrongly than they uſually do; in which caſe, the red particles and this lymph can ſeparate more eaſily from each other according to their denſities, the former falling to the bottom, and the greateſt part of the latter forming upon the upper ſurface a very viſcid tough maſs called the *buff*. By putrefaction the coagulable lymph and ſerum are converted into a mucilaginous matter, not coagulable by any of the methods recited above, which mucilaginous matter may be converted by further putrefaction into ſaline ſubſtances and calcareous earth. The red part of the blood is readily ſoluble in water, but not in ſerum, nor in a ſaturated ſolution of neutral ſalts. By the firſt ſtage of putrefaction this red part of blood is broken down into ſmaller particles, its color is rendered darker, and afterwards it is converted to a mucilage ſoluble in ſerum.

(d) BLUE COLORING MATERIALS. No blue materials for dying conſiſt of animal or mineral ſubſtances. Concerning the blue glaſs called *ſmalt*, prepared from the ore or regulus of cobalt; the preparation of iron called *Pruſſian blue*; and the preparation of lapis lazuli called *ultramarine* or *azure*, ſee SMALT, AZURE, *and* BLUE (PRUSSIAN). The *blue color of flowers* is ſo periſhable as to be of little uſe in dying. It is extracted from many by infuſion in water, but not in ſpirit. It is changed by acids to a red not more durable than the original blue; by marine acid to the moſt florid red; and it is changed by alkalis and by lime-water to a green, which afterwards becomes a yellow. The green by lime-water is the more permanent and beautiful, and has been formed into lakes for painting. The two principal vegetable ſubſtances uſed for dying of a blue color are *indigo* and *woad*. Theſe are feculæ or ſediments depoſited by fermentation from infuſions of the leaves of the plants *anil*, and *woad*, or *glaſtum*. Hellot thinks, that a ſimilar blue dye might be obtained from moſt other vegetables, and that the green of vegetables is cauſed by a mixture of blue and yellow coloring particles, of which the blue is the moſt durable, and leaſt affected by fermentations. The colors given by both indigo and woad are at firſt green, but are ſoon changed, by expoſure to air, to blue. A blue tincture may be made from *nephritic* wood, which has not been applied to any uſe. The *eſſential oils of camomile, milfoil, pimpinella nigra*, are blue, and by keeping become green and yellow. *See* DYING.

CXII. BLUE (PRUSSIAN). Pruſſian blue is a precipitate of iron with a ſuperabundant quantity of phlogiſton, from which it receives a very beautiful color.

This blue, which is ſucceſsfully uſed in painting, was diſcovered, like moſt other things, by accident, and about the beginning of this century.

A chemiſt of Berlin having ſucceſſively thrown upon the ground ſeveral liquors from his laboratory, was much ſurpriſed to ſee it ſuddenly ſtained with a moſt beautiful color. He then recollected what liquors he had thus thrown upon each other, and having made a ſimilar mixture in a veſſel, he ſaw the ſame blue color appear. As he perceived that this diſcovery might be profitable to him, he did not publiſh the proceſs, but prepared this blue for the uſe of painters, who found that it might be ſubſtituted for ultramarine, a very dear color, and from that time made much uſe of it.

An account of this blue, called *Pruſſian* or *Berlin blue*, from the place where it was made, was publiſhed in the Berlin Memoirs for 1710, but no deſcription was given of the proceſs for making it.

Several chemiſts undoubtedly attempted to diſcover it: accordingly it was diſcovered, and in the year 1724 Dr. Woodward publiſhed it in the Philoſophical Tranſactions. The proceſs ſucceeds very well, and is as follows:

Alkaliſe together four ounces of nitre and as much tartar. *See* ALKALI (EXTEMPORANEOUS). Mix this alkali well with four ounces of dried bullock's blood, and put the whole in a crucible covered with a lid in which there is a ſmall hole: calcine with a moderate fire till the blood be reduced to a perfect coal; that is, till it emits no more ſmoke or flame capable of blackening any white bodies that are expoſed to it: increaſe the fire towards the end, ſo that the whole matter contained in the crucible ſhall be moderately, but ſenſibly red.

Throw into two pints of water the matter contained in the crucible, while yet red, and give it half an hour's boiling: decant this firſt water, and pour more water upon the black and charry coal till it becomes almoſt inſipid: mix together all theſe waters, and reduce them by boiling to about two pints.

Alſo diſſolve two ounces of martial vitriol, and eight ounces of alum in two pints of boiling water: mix this ſolution when hot, with the preceding lixivium, alſo hot. A great efferveſcence will then be made. The liquors will be rendered turbid, and will become of a green color more or leſs blue, and a precipitate will be formed of the ſame color. Filtrate, in order to ſeparate this precipitate, upon which pour ſpirit of ſalt, and mix them well together, by which means the precipitate will become of a fine blue color. It is neceſſary to add rather too much ſpirit of ſalt than too little, and till it no longer encreaſes the beauty of the precipitate. The next day waſh this blue till the water comes off from it inſipid, and then gently dry it. Such is the proceſs by which Pruſſian blue is made. Chemiſts, after having diſcovered it, endeavored to find the theory of it, and to explain the appearances in the ſeveral operations of the proceſs. There have been ſeveral opinions concerning the nature of Pruſſian blue.

Mr. John Brown of the Royal Society of London thinks, that this blue is the bituminous or phlogiſtic part of iron, diſengaged by the lixivium of bullock's blood, and applied to the earth of alum. This opinion has been adopted by Dr. Geoffroy in the Memoirs given by him on this ſubject, which are found in the collection of the Academy of Sciences for the year 1725.

The Abbé Menon, a correſpondent of the Academy of Sciences, in Memoirs printed amongſt the collection of the *Sçavans Etrangers*, publiſhed by the Academy, advances and endeavors to prove that Pruſſian blue is nothing but iron entirely freed from all ſaline matter by the phlogiſton of the alkaline lixivium, and precipitated with its natural color, which, he pretends, is blue. He thinks that the uſe of the alum is to diminiſh the intenſity of the color by the whiteneſs of its earth.

Laſtly, Mr. Macquer, having examined this matter in all its extent, has publiſhed a memoir amongſt thoſe of the Academy of Sciences for the year 17[illegible], in which he concludes, after having related many experiments, that Pruſſian blue is nothing but iron impregnated with a ſuperabundant quantity of phlogiſton, which it receives from the phlogiſticated alkaline precipitant. The experiments and diſcoveries made by this chemiſt are as follow.

Mr. Macquer firſt obſerves that very pure alkaline ſalts ſeparate iron, as they do all metallic ſubſtances, from acids; and that iron ſo precipitated has a color more or leſs yellow, and is ſoluble by acids.

If, on the contrary, this precipitation of iron be made by an alkali previouſly calcined with an inflammable matter, then a precipitate is formed, more or leſs green or blue, as the alkali was more or leſs phlogiſticated.

If an acid be poured upon this green precipitate, experiments ſhew that the acid diſſolves one part of it, and does not act upon the other. This proves that the green precipitate is not homogeneous, but a mixture of two precipitates, one of which is ſoluble, and the other is inſoluble by an acid.

As the precipitate which reſiſts the action of acids is very blue, when ſeparated from that which the acid has diſſolved, and as the green color of the mixed precipitate is a mixture of yellow and blue; the author concludes that the part diſſolved by the acid is yellow, and conſequently that this portion of green precipitate is entirely ſimilar to the iron which pure alkalis ſeparate from acids.

As to the blue precipitate, as it not only reſiſts the action of acids but alſo of magnets, it might not be known to be iron, if a ſlight calcination did not at once deprive it of its blue color, and render it entirely ſimilar to other iron.

Theſe facts prove that Pruſſian blue is nothing but iron united with ſome matter which gives it a blue color, and the property of reſiſting the action of acids and of magnets.

Mr. Macquer has further diſcovered that fire is not the only means by which the Pruſſian blue may be deprived of all the properties, by which it differs from ordinary iron.

A very pure alkali produces alſo the ſame effect. He has alſo diſcovered, that the alkali which has thus deprived the Pruſſian blue of all the properties which diſtinguiſh it from ordinary iron, becomes by that operation entirely ſimilar to the phlogiſticated alkali uſed for the preparation of Pruſſian blue.

Theſe facts ſeem to demonſtrate that Pruſſian blue is nothing elſe than iron, which becomes blue by impregnating it with with a matter which the alkali is capable of giving to it or of ſeparating from it, according to circumſtances; that is to ſay, that when the alkali is impregnated with this matter, and is applied to iron diſſolved in an acid, it then combines with this acid, and precipitates the iron, to which it transfers at the ſame time the matter which changes the iron into Pruſſian blue. But if on the contrary Pruſſian blue be applied to pure alkali, then this alkali entirely diſſolves the coloring matter of the Pruſſian blue, and takes it from the iron, which is thus reduced to its ordinary condition.

By a more particular examination of this alkali, impregnated with the coloring matter of Pruſſian blue, either by calcination with an inflammable matter, or by taking the color from Pruſſian blue itſelf, Mr. Macquer found that its alkaline properties were ſo much more weakened, as it was impregnated with a larger portion of this coloring matter. This induced him to preſume, that by giving it a ſufficient quantity of Pruſſian blue to diſcolor, it might be entirely ſaturated with this coloring matter: and the event entirely anſwered his expectation.

By applying much Pruſſian blue to an alkali, this latter was ſo ſaturated that it no longer diſcolored the blue when boiled together, and upon trial, was found to poſſeſs no longer any alkaline qualities.

A ſolution of iron by any acid poured into this alkali, ſaturated with the coloring matter of the Pruſſian blue, forms immediately a precipitate, not green, compoſed of yellow and blue, the former of which muſt be ſeparated by an acid from the latter to obtain this of a pure blue color, as in the or
ceſs for the preparation of Pruſſian blue, but a ſingle homogeneous
and a perfect Pruſſian blue. This effect ought neceſſarily to happ
the ſaturated alkali contains no part purely alkaline which can occaſion a precipitate of ſoluble iron, as pure alkalis do.

But an eſſential phenomenon, and not obſerved by any former chemiſt, is, that it is not merely by the action of the acid, which diſſolves the iron, that the coloring matter is applied to the iron, and thus the Pruſſian blue formed; but that the affinity of this matter to iron contributes alſo to produce this effect. The author has demonſtrated this truth by the following deciſive experiment.

If any pure acid be poured upon an alkali perfectly ſaturated with the coloring matter of Pruſſian blue, this acid contracts no union with this alkali, nor is any-ways neutralized, and conſequently is incapable of ſeparating the coloring matter of Pruſſian blue. It only procures this ſeparation when it is united with iron, the affinity of which to the coloring matter, being joined to the affinity of the acid to the alkali, form a ſum of affinities capable of occaſioning the ſeparation of which we treat.

In this operation, therefore, there is a very diſtinct example of the effect of double or united affinities. *See* AFFINITY. This example is even ſo much more compleat, as it is amongſt the moſt general that chemiſtry furniſhes. For according to Mr. Macquer's obſervations, iron is not the only metallic ſubſtance, the affinity of which being united with that of the acid, procures the ſeparation of the coloring matter of the Pruſſian blue from the alkali; but any metalic ſubſtance diſſolved in any acid ſeparates the phlogiſtic matter from all alkalis, fixed or volatile. This is aſcertained by Mr. Macquer's experiments, a detail of which may be ſeen in his memoir.

Another no leſs important phenomenon, which none of the chemiſts who have endeavored to explain the theory of Pruſſian blue had obſerved, is, that earths have not the ſame affinity as metallic ſubſtances with the phlogiſtic matter of Pruſſian blue. Hence if an alkali ſaturated with this coloring matter be poured into a ſolution of alum, no decompoſition is effected, nor is any precipitate formed. The alum continues alum, and the ſaturated alkali remains unchanged.

After this experiment Mr. Macquer reaſonably concludes, that the alum added in the operation of Pruſſian blue does not directly contribute to the production of this blue. The purpoſe to which it ſerves is as follows.

This chemiſt proved by many experiments, that alkali ſalt can never be entirely ſaturated with the coloring matter of Pruſſian blue by calcination. This being eſtabliſhed, it is certain that alkalis, calcined with inflammable ſubſtances to make the proper lixivium for Pruſſian blue, ſtill remain alkaline. Hence it happens that when they are mixed with a ſolution of green vitriol, they form by their purely alkaline part a yellow precipitate, ſo much more copious as this purely alkaline part is itſelf more copious. But nothing is more capable of ſpoiling the color of the portion of iron precipitated in Pruſſian blue than a mixture of this yellow or olive-colored precipitate; therefore a large quantity of acid muſt be employed, that this yellow precipitate may be entirely diſſolved, if we mean to have a very fine blue.

Part of theſe inconveniencies is avoided by mixing a ſolution of alum with a ſolution of green vitriol. By this means, the purely alkaline part of the lixivium is moſtly employed to precipitate a greater or leſs quantity of the earth of alum, and conſequently the quantity of yellow ferrugineous precipitate is much diminiſhed. But the earth of alum being of a fine ſhining white does not in the leaſt alter the purity of the blue color, but enlivens it, and leſſens its intenſity; which is frequently no inconvenience, becauſe the Pruſſian blue, when it is not of the fineſt color, is always too dark and black.

It follows from what has been ſaid, that when Pruſſian blue is to be made with a lixivium not ſaturated, it is a matter of indifference whether the green precipitate is to be again diſſolved, or the alkaline part of the lixivium ſaturated with alum or with an acid, before the precipitate is formed. The only difference which can proceed from theſe modes of management is, that in the former caſe all the part of the precipitate which is not Pruſſian blue is rediſſolved by an acid; whereas in the latter caſe, this mixed precipitation is prevented, and nothing is thrown down but true Pruſſian blue.

It is proper to obſerve, concerning the theory of Pruſſian blue, that moſt alkalis obtained from the aſhes of vegetables, being combined by their combuſtion with a portion of inflammable matter, are capable of furniſhing a quantity of Pruſſian blue proportionable to the quantity retained by them of this inflammable matter, even without the neceſſity of mixing them with a ſolution of iron, becauſe they always contain a little of this metal diſſolved, ſome of which may be found in almoſt all vegetables; therefore it is ſufficient for this purpoſe to ſaturate them with an acid. Theſe materials which form Pruſſian blue in alkaline ſalts occaſion their impurity, and require much trouble to be perfectly ſeparated.

Some chemiſts had even perceived the production of this blue in the ſaturation of alkaline ſalts, before the diſcovery of the Pruſſian blue: and Henkel particularly, who had obſerved it in the ſaturation of ſal ſoda, or foſſil alkali, recommended to chemiſts an enquiry concerning the nature of this blue. Thus chemiſts had already acquired ſome ſort of knowledge on this ſubject, and therefore the Pruſſian blue could not have long remained unknown, even if accichance had not preſented it in ſo ſtriking a manner to the chemiſt of Berlin, who was the firſt who prepared it in ſufficient quantity for the uſes of painters.

CXIII. BOLE. Boles, or bolar earths, are clays which adhere to the tongue, when applied dry, and which are colored, yellow and red, by a ferruginous earth. *See* Clay.

CXIV. BOLOGNIAN STONE. *See* Stone.

CXV. BONES. (*c*)

CXVI. BORAX. Borax is a ſaline matter, with all the properties of a [illegible]

It is ſoluble in water, and cryſtallizable nearly as alum is; with this difference only, that it requires a little more water for its ſolution, and retains ſomewhat leſs in its cryſtallization.

When expoſed to fire, it at firſt undergoes the liquefaction occaſioned by the water of its cryſtallization, and is then calcined, as alum is, but is not ſo much ſwelled and rarefied during the operation.

If the fire be increaſed to a melting heat, the borax is pretty eaſily fuſed, and is converted into a vitreous matter, or ſaline glaſs: and when it is mixed with earths of any kind, it acts as a flux, and converts them into more or leſs tranſparent glaſſes according to their natures. *See* Vitrification.

Glaſs of borax is very friable, eaſily tarniſhes in the air, and becomes mealy, nearly as the alkaline baſis of ſea-ſalt does. It is entirely ſoluble in water; and when the ſolution of it is evaporated, borax is again formed in cryſtals, as it was before its fuſion.

Borax then ſuffers no decompoſition by fire, even in open veſſels, and certainly, therefore, not in cloſe ones.

But it may be decompoſed by the vitriolic, nitrous, and marine acids, which unite with the ſaline alkaline matter which is its baſis, and form with it exactly the ſame neutral ſalts as thoſe which reſult from the union of theſe acids with the marine alkali; that is to ſay, the vitriolic acid forms Glauber's ſalt; the nitrous acid forms cubic nitre; and the marine acid forms ſea-ſalt.

When acids combine thus with the alkaline baſis of borax, they ſeparate from it a ſaline ſubſtance of a ſingular nature, and little underſtood, called *Sedative Salt*. *See* Salt (Sedative.)

We are far from knowing as much concerning borax as is deſirable. We are even ignorant of its origin, which might ſupply the want of a perfect analyſis, and give light to the nature of this ſaline ſubſtance.

As borax is not found in Europe, it is brought from the Eaſt-Indies in a ſtate which only requires a ſlight purification, which is given to it by the Dutch and

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(*c*) Bones are totally ſoluble in concentrated acids of vitriol, nitre, and ſea-ſalt, and may be ſoftened by theſe or acetous acids diluted. From two ounces of ox-bone Neumann obtained by diſtillation two drams of empyreumatic phlegm, one dram of volatile urinous ſpirit, two ſcruples of volatile alkali, two ſcruples of fetid oil, and one ounce, three drams, and two ſcruples of reſiduum. Dr. Lewis obſerves, that bones expoſed to a heat gradually raiſed are rendered white, opake, and friable; and when expoſed ſuddenly to a violent heat, are rendered hard, ſemi-tranſparent, and ſonorous. Bones and horns may be ſtained by the common dying infuſions and decoctions of vegetable and animal ſubſtances, and by metallic ſolutions.

Venetians who are the chief merchants of it. But it is not yet known whether this matter be a natural or an artificial ſubſtance, nor whence, nor how it is obtained.

Our ignorance concerning borax is certainly owing to the intereſt, which they, who make a lucrative commerce of it, have to keep every thing concerning its origin ſecret.

However that be, notwithſtanding the reſources which chemiſts poſſeſs of diſcovering what is hid from them by their experiments, it appears that they were long in a ſtate of indifference concerning borax. Satisfied with employing it in their operations, in which it is very uſeful as a flux, they long uſed it without attempting to ſubject it to proper proofs for the diſcovery of its nature.

In the writings of Becher and Stahl we ſcarcely find any thing concerning borax. The examination by chemical means of this ſubſtance, which ought to excite the curioſity of chemiſts, has been begun only in theſe latter times; and it is to the praiſe of the French, that almoſt all the knowledge we have concerning it we owe to them alone.

Homberg was amongſt the firſt who undertook a ſet of experiments on borax, by which the ſedative ſalt was diſcovered, which was a new ſubſtance, and entirely unknown before him. Homberg obtained the ſedative ſalt from borax. by diſtilling it with vitriol; and imagining that he diſcovered a ſedative or quieting power in it, he called it the *Narcotic Salt of Vitriol*, or *Sedative Salt*. This chemiſt did not well underſtand the theory of his experiment; but that is not ſurpriſing in matters ſo new.

The younger Lemeri, who after Homberg made many experiments on borax, diſcovered that ſedative ſalt may be obtained from it not only by the vitriolic acid, but alſo by the nitrous and marine acids. This diſcovery was the more important, as it naturally led to further: but he ſeems to have been prevented by other purſuits from continuing this ſubject as it ought to be.

Homberg and Lemeri obtained ſedative ſalt only by diſtillation or ſublimation, which, particularly in this caſe, was a long and embarraſſing operation. M. Geoffroy has improved upon their diſcoveries, by ſhewing the method of obtaining the ſame ſalt from borax by acids with evaporation and cryſtallization only, in greater quantity and with leſs trouble We are alſo obliged to him for having firſt demonſtrated that borax contains the baſis of ſea-ſalt. This truth he has firmly eſtabliſhed, by obtaining a true Glauber's ſalt by mixing vitriolic acid with a ſolution of borax.

Laſtly, Mr. Baron, Member of the Academy of Sciences, and of the Faculty of Medicine at Paris, proved by many experiments that ſedative ſalt of borax may be obtained by means of vegetable acids, which had not been done before him. He has alſo proved, that ſedative ſalt is not a combination of an alkaline matter with the acid employed to obtain it, but that it exiſts ready formed in borax, of which it is a principle or conſtituent part; that the acids employed to extract it do only diſengage it from the alkali with which it is united; that this alkali is entirely ſimilar to that of ſea-ſalt; that ſedative ſalt may be re-united with its alkali, and again form borax; which is a compleat proof that borax is nothing elſe than a compound of ſedative ſalt, and marine alkali.

Nothing more then remains to have, on the nature of borax, all the knowledge we can deſire, than to diſcover what this ſedative ſalt is. The experiment by which Mr. Baron found that this ſalt is capable of decompoſing nitre and marine ſalt, by ſeparating the acids of theſe ſalts by help of fire, ſeems to ſhew that vitriolic acid is one of the principles of the ſedative ſalt. But to prove this deciſively, the ſedative ſalt itſelf muſt be decompoſed. This is the ſubject of Mr. Bourdelin's late admirable experiments. Although this able chemiſt has not been able to accompliſh his purpoſe by all the methods which the moſt profound chemiſtry can ſuggeſt, his experiments are nevertheleſs uſeful, as they may prevent others from employing their time and labor in making them, and alſo becauſe they make us better acquainted with the properties of the ſedative ſalt. *See* SALT (SEDATIVE). *(f)*

CXVII. BRAINS. *(g)*

CXVIII. BRANDY. *(h)*

(f) *Borax*, when crude, as it is brought from the Eaſt-Indies, is called *Tincal*. In this ſtate, it conſiſts of ſmall, yellow, glutinous cryſtals. It is ſaid to be refined by lime water. Refined borax conſiſts of large, white, eight-ſided cryſtals, each of which is compoſed of ſmall, ſoft, bitteriſh ſcales. It is difficultly ſoluble in water, to which it gives a glutinous quality, and hence is uſed by dyers to give a gloſs to ſilks. It is alſo ſoluble in ſpirit of wine, to the flame of which it gives a green color. By repeatedly moiſtening it, while it is conſiderably heated, it may be entirely ſublimed. Borax renders all earths and ſtones fuſible by fire, and hence is uſed for the eſſaying of ores. It alſo facilitates the fuſion of metals; and is particularly uſeful when ſmall particles of metal mixed with dirt and aſhes are to be melted together; as it promotes the fuſion of the metal, and the vitrification of the other matters, by which the particles of metal may diſengage themſelves, and collect into one maſs. It is further uſeful in the fuſion of metals, as it defends their ſurfaces from the combined action of air and fire, by which imperfect metals are calcined. Crucibles in which gold and ſilver are melted ought to be previouſly glazed on their inner ſurfaces with borax, that when the metals are poured out, no particles may adhere to the ſides of the crucibles. Gold is rendered pale by fuſion with borax, which effect is prevented by adding a little nitre or ſal-ammoniac, or is remedied by remelting the gold with either of theſe ſalts. Dr. Lewis obſerves, that borax alſo renders braſs and Prince's-metal pale, and at the ſame time acquires a deep red color. This color it probably receives from ſome part of the copper contained in theſe compound metals, as it acquires the ſame red color by fuſion with copper. Borax is not, as ſome ſuppoſe, a ſubſtance capable of reducing or reviving calcined metals, but is [illegible] principal uſe of borax is to facilitate the ſoldering of metals, which it does by accelerating the fuſion of the ſurfaces of the metals to be joined, and by clearing them from any calx or other matter by which they might be prevented from being perfectly applied to each other. Borax is alſo uſed for the preparation of ſome fine glaſſes, and imitations of precious ſtones; becauſe the glaſſes prepared by fuſing it with earths are very hard, compact, bright, and very tranſparent; but by long expoſure to air they loſe much of their luſtre, become cloudy, and when the quantity employed has been large, even opake.

(g) BRAINS. From 16 oz. of ox's brains, Neuman obtained by diſtillation ſix ounces, two drams, and two ſcruples of a colorleſs phlegm; four ounces and four ſcruples of a volatile, empyreumatic ſpirit; which being rectified, produced two ſcruples of a volatile, concrete ſalt, and one ounce of caput mortuum, from which, by elixation, were procured 25 grains of fixed ſalt.

(h) BRANDY is an ardent ſpirit diſtilled from wine. For its properties, *ſee* SPIRIT. It may be imitated by adding to very pure malt ſpirits ſome dulcified ſpirit of nitre.

CXIX. BRASS (*i*). Braſs, called alſo *Latten*, is a mixture of very pure copper, with a fourth part of very pure zinc, by which the color of the copper is rendered of a fine golden yellow. This is undoubtedly the moſt uſeful and neceſſary of all the mixtures of copper and other metals, chiefly on account of the copper's preſerving ſo much of its ductility, when combined with that proportion of zinc.

(*i*) Braſs. As the manufacture of braſs is important in commerce, a detail of the proceſs by which it is made may be acceptable. The calamine is previouſly to be prepared by cleanſing it from adhering earth, ſtone, or other matters; by roaſting or calcining it; and by grinding it into a fine powder. The calcination, by which moiſture and ſmall portions of ſulphur and other volatile matters are diſſipated, may be performed either in a reverberatory furnace, in which the calamine is kept till it be thoroughly red hot; and that this heat may be more equally given to it all at the ſame time, it ought to be frequently ſtirred; or by ſetting fire to a conical pile, compoſed of horizontal layers of calamine, and of charcoal placed alternately one upon the other, and of a lower ſtratum conſiſting of large pieces of wood; in which lower ſtratum are four horizontal channels, through which the air maintaining the fire paſſes to the center, and thence ariſes through a chimney or perpendicular empty ſpace, left for that purpoſe, along the axis of the conical pile. If the calcining heat be too intenſe or too long continued, part of the contained zinc may be diſſipated; and if it be not ſufficiently intenſe, or long enough continued, the volatile matters will not be entirely expelled, and the texture of the ſtone will not be ſufficiently broken to prepare it for the ſubſequent grinding. The length of time and degree of heat requiſite for the calcination of calamine, are different according to the qualities of that mineral. The calamine thus cleanſed, calcined, and ground, is to be mixed with about a third or fourth part of powder of charcoal, or of pit-coal, as is done in ſome parts of England. The malleability of the braſs is diminiſhed by the uſe of pit-coal, which is therefore employed only for the preparation of coarſer kinds of braſs. To this compoſition of calamine and coal ſome manufacturers add common ſalt, by which the proceſs of making braſs is ſaid to be haſtened. In Goſlar, where the cadmia adhering to the inner ſides of furnaces is employed, inſtead of native calamine, a ſmall quantity of alum is added, by which they pretend the color of the braſs is heightened. With this compoſition, and with thin plates or grains of copper, the crucibles are to be nearly filled. The proportion of calamine to the copper varies according to the richneſs of the former, but is generally as three to two. The copper muſt be diſperſed through the compoſition of calamine and coal, and the whole muſt be covered with more coal till the crucibles are full. The crucibles thus filled are to be placed in a furnace ſunk in the ground, the form of which furnace is that of the fruſtum of a hollow cone. At the bottom of the furnace, or greater baſis of the fruſtum, is a circular grate, or iron plate. This plate is covered with a coat of clay and horſe-dung to defend it from the action of the fire, and pierced with holes, through which the air maintaining the fire paſſes. The crucibles ſtand upon the circular plate, forming a circular row with one in the middle. The fuel is placed betwixt the crucibles, and is thrown into the furnace at the upper part of it, or the leſſer baſis of the fruſtum. To this upper part or mouth of the furnace is fitted a cover made of bricks or clay, kept together by bars of iron, and pierced with holes. This cover ſerves as a regiſter. When the heat is to be encreaſed, the cover is to be partly or entirely taken off, and a free draught is permitted to the external air, which paſſes along a vault under ground to the aſh-hole, through the holes in the circular grate or plate, betwixt the crucibles, and through the upper mouth along with the ſmoke and flame into an area where the workmen ſtand, which is covered with a large dome or chimney through which the ſmoke and air aſcend. When the heat is to be diminiſhed, the mouth of the furnace is to be cloſed with the lid, through the holes in which the air, ſmoke, and flame paſs. The crucibles are

Although zinc be only a ſemi-metal, and conſequently not ductile, and although metallic mixtures be generally leſs ductile than the pure metals of which they are compoſed, zinc ſeems to be an exception to this rule in its combination with copper; for it has the property of uniting with that metal in a large proportion, as of a third, or a fourth, without ſenſibly diminiſhing the ductility of the copper. But as this property is quite peculiar to zinc, it is evident that it is neceſſary, in order to make good braſs, that the copper and zinc be, each of them, in their greateſt purity.

If ſuch zinc as is procured in the ſmelting of ores be melted with copper, as in ſome mixtures commonly uſed, we might indeed obtain a very fine-colored braſs, but it would be brittle and unmalleable. It would only be a mixture of that kind called *tombacs*, becauſe this zinc is never very pure. *See* ZINC.

This inconvenience is avoided in making braſs, by a kind of cementation with the ore of zinc, which is lapis calaminaris. This proceſs is performed in the following manner.

A cement, compoſed of one part and a half of good lapis calaminaris and powder of charcoal triturated together, and moiſtened with water, is put into an earthen pot or crucible. Then one part of very pure copper beat into

to be kept red-hot during eight or ten hours, and in ſome places much longer, even ſeveral days, according to the quality of the calamine; during which time the zinc riſes in vapor from the calamine, unites with the copper, and renders that metal fuſible by conſiderably leſs heat than it is alone. To render the metal very fluid, that it may flow into one uniform maſs at the bottom, the fire is to be encreaſed a little before the crucibles are taken out for the pouring of the fluid metal into moulds. From ſixty pounds of good calamine and forty pounds of copper, ſixty pounds of braſs may by this proceſs be obtained, notwithſtanding that a conſiderable quantity of zinc is burnt and diſſipated during the operation; as we may learn from the blue flame round the mouths of the crucibles and furnaces, from the flowers of zinc which adhere to the inner ſides of the furnace, and from the blue color communicated to the crucibles. The quantity of braſs obtained has been conſiderably augmented ſince the introduction of the method now commonly practiſed of uſing granulated copper, by which a larger ſurface of this metal is expoſed to the vapor of [illegible] zinc, and conſequently leſs of that vapor eſcapes. For the granulation of the copper, a cylindrical wooden reſervoir is made, four or five feet deep, in which a circular braſs or copper bottom may be raiſed or lowered, by means of a chain. This reſervoir is covered with a copper lid, in the middle of which is a hole half a foot in diameter, intended to receive an iron ladle pierced with holes, and coated with clay. The reſervoir being filled with water, the melted copper is poured through the holes in the ladle into the water; where it is broken by its fall into ſmaller drops or grains, is rendered ſolid by the cold water, and is collected in the moveable bottom, which is afterwards to be raiſed by the annexed chain, that the granulated copper may be taken out.——The above is the proceſs generally employed for making braſs. But to make the finer and more malleable kinds of braſs, beſides the choice of pure calamine and pure copper, ſome manufacturers cement the braſs a ſecond time with calamine and charcoal, and ſometimes add to it old braſs, by which the new is ſaid to be meliorated.

Braſs is brittle when hot, but is ſo ductile when cold that it may be drawn into very fine wire. Its beautiful color, its hardneſs, its malleability, its fuſibility, by which it may be eaſily caſt into moulds, and its quality of being leſs ſubject to ruſt or verdigriſe than copper, render it fit for the fabrication of many utenſils.

plates, is placed over the cement, and the whole is covered with charcoal duſt. The crucible is then cloſed, and is heated only enough to make it gradually become red. When the flame of the coals has acquired a cupreous color, an iron rod is introduced into the crucible, to try if the copper be melted under the cementing powder. If that be the caſe, the action of the fire is moderated, and in a few minutes the crucible is taken out.

When it is cooled, the copper is found to have become yellow, and to have received an augmentation of a fourth, and ſometimes of a third of its weight, and is nevertheleſs very malleable.

This proceſs is, as we ſee, a kind of cementation, in which the zinc is raiſed from its ore in vapors, and combines with the copper. This method is advantageous, principally becauſe the other metallic matters, and particularly the iron, from which lapis calaminaris is ſeldom free, do not riſe in vapors, and conſequently cannot combine with the copper.

In order to effect this purpoſe more certainly, the cementing powder may be mixed up with clay into a paſte; which being put in the bottom of the crucible, is to be covered with plates of copper and charcoal powder, proceeding as is directed above. The copper, penetrated by the vapors of the zinc which paſs through the paſte, melts upon the ſurface of the paſte, and does not mix with the other metals, which always alters the color and ductility of the braſs. Theſe proceſſes are from M. Cramer.

The advantages of converting copper into braſs are, that its weight is augmented one fourth part; that its color is changed to one more agreeable, as it approaches the color of gold; that it is more fuſible; and laſtly, that it is leſs ſubject to ruſt, becauſe zinc is leſs ſuſceptible than copper of being altered by the action of air and of water.

Although zinc be fixed to a certain degree in braſs by the adheſion it contracts with the copper, yet when braſs is melted and expoſed to a violent fire during a certain time, the zinc diſſipates in vapors, and even flames away, if the heat be ſtrong enough; and if the heat laſts long enough, all the zinc will be evaporated and deſtroyed, ſo that what remains is copper.

Copper, or copper converted into braſs, or in any other form, but particularly when penetrated by any ſalts and reduced into verdigriſe, produces always, when taken internally, the moſt troubleſome conſequences, and becomes a poiſon. For this reaſon it is dangerous to uſe copper utenſils and veſſels for the purpoſe of cookery, and in many places they begin to be diſuſed.

For the ſame reaſon alſo, none of the preparations of this metal are ever employed medicinally by prudent phyſicians. It appears, however, to enter into the compoſition of a remedy much uſed, the *Lilly of Paracelſus*, or *Tincture of Metals*: but in fact, it is certain that the ſpirit of wine, employed for the preparation of this medicine, diſſolves nothing of the calx of copper, or of the other calxes of metallic ſubſtances digeſted in it. Mr. Beaumé convinced himſelf of this fact by a moſt accurate examination of the *Lilly of Paracelſus*.

The beſt remedies for perſons poiſoned by verdigriſe are, mild, watery, mucilaginous, and oily drinks, given quickly and copiouſly, which ought to be immediately ſucceeded by evacuants to carry off the poiſon as faſt as is poſſible.

The uſe of copper then in medicine is confined to external applications. It is ſtimulant, tonic, and deterſive. Verdigriſe enters into the ungentum Egyptiacum, into ſeveral plaſters, the collyrium of Lanfranc, and the green balſam of Metz. A blue water for the eyes is made with copper and ſal ammoniac, which is called *Celeſtial water*.

CXX. BREAD. The grains of all vegetables are almoſt entirely compoſed of ſubſtances very proper for the nouriſhment of animals; and amongſt grains thoſe which contain a farinaceous matter are the moſt agreeable and moſt nutritive.

Man, who appears to be deſigned by nature to eat of all ſubſtances which are capable of nouriſhing him, and ſtill more of vegetables than animals, has, from time immemorial, and in all parts of the earth, uſed farinaceous grains as the principal baſis of his food: but as theſe grains cannot be without difficulty eaten by men in their natural ſtate, this active and intelligent animal has gradually found means not only to extract the farinaceous part, that is, the only nutritive part of theſe grains, but alſo to prepare it ſo that it becomes a very agreeable and wholeſome aliment, ſuch as the bread we now generally eat.

Nothing appears ſo eaſy at firſt ſight as to grind corn, to make a paſte with the flour and water, and to bake this paſte in an oven. They who are accuſtomed to enjoy the advantages of the fineſt human inventions, without reflecting on the labor it has coſt to compleat them, think all theſe operations common and trivial. However, it appears very certain, that for a long time men no otherwiſe prepared their corn than by boiling and forming compact, viſcous cakes, not very agreeable to the taſte, and of difficult digeſtion, before they were able to make bread of good taſte and quality, as we have now. It was neceſſary to invent and compleat ingenious machines for grinding corn, and ſeparating the pure flour with little trouble and labor; and that inquiries, or rather ſome happy chance, which ſome obſerving perſon availed himſelf of, ſhould diſcover that flour mixed with a certain quantity of water is ſuſceptible of a fermentation, which almoſt entirely deſtroys its viſcidity, heightens its taſte, and renders it proper to make a light bread, very agreeable to the taſte, and of eaſy digeſtion.

This eſſential operation, on which the good quality of bread depends, is entirely of the province of chemiſtry. It would add to the honour of the ancient cultivators of chemiſtry, to attribute to them ſo uſeful and important a diſcovery; but unhappily it is too probable that they had no ſhare in it. The ancient chemiſts were engaged in other purſuits than that of bread and other common objects. They hoped to make gold; and what is bread in compariſon with gold?

However that be, to the fortunate invention of raiſing the paſte before baking we owe the perfection of the art of making bread. This operation conſiſts in keeping ſome paſte or dough, till by a peculiar ſpirituous fermentation it ſwells, rarefies, and acquires a ſmell and taſte quick, pungent, ſpirituous, ſomewhat ſour, and rather diſagreeable. This fermented dough is well worked with ſome freſh dough, which is by that mixture, and moderate heat, diſpoſed to a ſimilar, but leſs advanced fermentation than that above-mentioned. By this fermentation the dough is attenuated and divided, air is introduced into it, which being incapable of diſengaging itſelf from the tenacious and ſolid paſte, forms in it ſmall cavities, raiſes and ſwells it: hence the ſmall quantity of fermented paſte which diſpoſes the reſt to ferment, is called *leaven*, from the French word *lever*, ſignifying to raiſe.

When the dough is thus raiſed, it is in a proper ſtate to be put into the oven, where, while it is baked, it dilates itſelf ſtill more by the rarefaction of the air, and of the ſpirituous ſubſtance it contains, and it forms a bread full of eyes or cavities, conſequently light, and entirely different from the heavy, compact, viſcous, and indigeſted maſſes made by baking unfermented dough,

The invention of beer, or wine of grains, furniſhes a new matter uſeful in the making of bread. This matter is the froth which forms upon the ſurface of theſe liquors during fermentation. When it is mixed with dough, it raiſes it better and more quickly than ordinary leaven. It is called *yeaſt* or *barm*. By means of this the fineſt, lighteſt bread is made. It often happens that bread made with leaven dough has a ſouriſh and not agreeable taſte, which may proceed from too great a quantity of leaven, or from leaven in which the fermentation has advanced too far. This inconvenience does not happen to bread made with yeaſt; becauſe the fermentation of this ſubſtance is not too far advanced, or becauſe more attention is given to that finer bread.

It may be aſked, why, ſince dough is capable of fermenting ſpontaneouſly and ſingly, as we ſee from the leaven, a ſubſtance is added to diſpoſe it to ferment. The true reaſon is, that all the parts of a fermenting ſubſtance do not ferment at the ſame time, nor to the ſame degree; ſo that ſome parts of this ſubſtance have finiſhed their fermentation while others have not yet begun. The fermentable liquors which contain much ſugar, as hydromel, and muſt of wines, give proofs of this truth; for, after theſe liquors have become very vinous, they have ſtill very diſtinctly a ſaccharine taſte: but all ſaccharine matter is ſtill ſuſceptible of fermentation; and, in fact, if vinous hydromel, or muſt, or even new beer, be diſtilled, ſo that all their ardent ſpirit ſhall be ſeparated, and the reſiduums diluted with water, we ſhall ſee a ſecond fermentation take place, and a new quantity of ardent ſpirit formed.

The ſame thing preciſely happens to dough, and ſtill more ſenſibly, from its viſcoſity and want of fluidity; ſo that if it be left to ferment alone, and without the help of leaven, as the fermentation proceeds very ſlowly and ſucceſſively, the parts which ferment firſt will have become ſour and vapid before all the reſt be ſufficiently attenuated and changed, by which the bread will acquire a diſagreeable taſte.

A mixture of a ſmall quantity of leaven with dough effectually prevents this inconvenience; becauſe the effect of this leaven, and of all fermenting ſubſtances, is to diſpoſe to a ſimilar fermentation all matters capable of it, with which it is mixed; or rather, by means of leaven, the fermentation of all the parts of ſuch ſubſtances is effected more nearly at the ſame time.

Bread well raiſed and baked differs from unfermented bread, not only in being leſs compact, lighter, and of a more agreeable taſte, but alſo in being more eaſily miſcible with water, with which it does not form a viſcous maſs, which circumſtance is of great importance in digeſtion.

CXXI. BRONZE. Bronze is a compound of copper and tin, to which ſometimes other metallic ſubſtances, particularly zinc, are added.

Bronze is brittle, hard, and ſonorous. It is employed for various uſes, as for making bells, cannons, and ſtatues; and the proportions of the component metals are varied to ſuit the ſeveral uſes to which it is applied.

The compound of copper and tin has a greater than the intermediate ſpecific gravity. Two ounces of a metal compoſed of four-fifths of pure copper, and one fifth of pure tin have ſeven grains and the tenth of a grain more of ſpecific gravity, than the ſame quantities of theſe two metals not allayed have. (*k*) This proves that in the union of copper and tin there is a penetration of parts; that is, that one metal enters into the pores of the other. Perhaps even this effect is reciprocal.

Many chemiſts, and particularly Glauber and Becker, have a long time ago remarked, that the ſpecific gravities of metallic allays differed more or leſs from what they ought to be, if there were no penetration, and that ſometimes the effect is contrary. But lately this matter has been treated with more preciſion. Several good chemiſts, ſuch as Eiſporn, Hahn, Krafft, and Gellert, have given reſults of well conducted experiments on this ſubject. *See Gellert's Metallurgic Chemiſtry. See the words* ALLAY, GRAVITY (SPECIFIC).

Mr. Tillet, member of the Royal Academy of Sciences, obſerves, in his Memoir concerning the ductility of metals, that when the mixture of copper with tin is made in the proportions above-mentioned, the color of the copper is entirely annulled and covered by that of the tin, although the quantity of copper be four times the quantity of tin. This ſingular effect cannot be underſtood without admitting a total change in the ſize and diſpoſition of the pores of the compound metal; which conſequently is a new proof of the reciprocal penetration of the two metals.

As tin is leſs ſenſible to the action of ſalts, of moiſture, and of the air, than copper, it is alſo leſs liable to ruſt: hence bronze is leſs apt to be covered with verdigriſe than pure copper is. This is one reaſon why this allay is uſed for cannons, ſtatues, and works expoſed to the air and weather.

The greater fuſibility of bronze than of copper is alſo an advantageous property, and much facilitates the caſting of large works, as ſtatues, bells, and cannon.

Laſtly, a phenomenon worthy of attention is, that tin, though greatly ſofter and leſs ſonorous than copper, nevertheleſs renders this metal, by being allayed with it in a proper proportion, more hard and more ſonorous: hence this allay is uſed for bells.

The operation by which large works of bronze are caſt is ſufficiently ſimple. For this purpoſe a brick furnace is uſed, nearly of the ſhape of an oven for baking bread. The floor of this furnace is concave, and conſiſts of a compoſition of ſand and clay. In this hollow floor the metals to be fuſed are put. The furnace has three openings.

The firſt is a lateral mouth, at which enters the flame of wood placed in a ſecond furnace on one ſide of the firſt; the ſecond opening is a chimney placed on the ſide oppoſite to the mouth, by means of which the flame is drawn over

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(*k*) The author means, I ſuppoſe, that a metallic maſs, weighing two ounces, compoſed of four-fifths of copper and one fifth part of tin, weighs, in water, 7$\frac{1}{10}$ grains more than the ſame quantities of theſe two metals would together weigh, in water, if not allayed.

the metal. The third opening is a hole which is opened and ſhut at pleaſure, through which the inner part of the furnace may be occaſionally inſpected, that the ſtate of the metal may be obſerved. When the metal is in the ſtate required, a fourth opening is then uncloſed, communicating with the hollow floor, and through which the melted metal flows by channels into the moulds prepared to receive it.

CXXII. BRYONY. (l)

CXXIII. BURDOCK. (m)

CXXIV. BUTTER. Butter is the fat, oily, and inflammable part of milk. This kind of oil is naturally diſtributed through all the ſubſtances of the milk, in very ſmall particles, which are interpoſed betwixt the caſeous and ſerous parts, amongſt which it keeps itſelf ſuſpended by a ſlight adheſion but without being diſſolved. It is in the ſame ſtate in which oil is, in emulſions; hence the ſame whiteneſs of milk and emulſions, and hence by reſt the oily parts ſeparate from both theſe liquors to the ſurface, and form a cream. *See* Emulsion.

When butter is in the ſtate of cream, its proper oily parts are not yet ſufficiently united together to form a homogeneous maſs. They are ſtill half-ſeparated by the interpoſition of a pretty large quantity of caſeous and ſerous particles. The butter is compleatly formed by preſſing out theſe heterogeneous parts by means of continued percuſſion. It then becomes an uniform ſoft maſs.

Freſh butter, which has undergone no change, has ſcarcely any ſmell; its taſte is mild and agreeable; it melts with a weak heat, and none of its principles are diſengaged by the heat of boiling water. Theſe properties, together with that of not inflaming but with a heat greater than that of boiling water, capable of decompoſing it, and reducing it to vapors, prove that the oily part of butter is of the nature of the mild, fat, and fixed oils obtained from many vegetable ſubſtances by expreſſion. *See* Oils (Sweet Expressed).

The half fluid conſiſtence of butter, as of moſt other concrete oily matters, is cauſed by a conſiderable quantity of acid, united with the oily part: but this acid is ſo well combined, that it is not ſenſible while the butter is freſh, and has undergone no change; but when it grows old, and undergoes ſome kind of fermentation, then the acid is diſengaged more and more; and this is the cauſe that butter, like oils of the ſame kind, becomes rancid by age.

The acid of butter is more quickly and ſenſibly diſengaged by fire. If butter be expoſed to a degree of fire ſtrong enough to make it ſmoke, vapors are exhaled from it inſupportably acrid, which draws tears from the eyes, and excite coughing, as may be daily obſerved in kitchens. Theſe vapors are nothing elſe than the diſengaged acid. The remaining part of the butter after this operation has a ſtrong taſte, very different from its former mildneſs; becauſe the part of the acid which is not exhaled is become ſenſible and half-diſengaged by the action of the fire. The ſame thing preciſely happens when butter is diſtilled in a retort.

(l) Bryony. From two ounces of this plant Neuman obtained by water ten drams of gummy extract, and from the ſame quantity he obtained by ſpirit two drams two ſcruples and a half of reſinous extract.

(m) Burdock Root. From 16 drams of this root Neuman extracted by water 7 drams 52 grains, and from an equal quantity of it by ſpirit he extracted 5 drams and 50 grains.

To decompoſe butter by diſtillation, a much greater heat than that of boiling water muſt be applied to it: acid vapors are then raiſed of conſiderable volatility and acrimony. Theſe vapors are accompanied with a ſmall portion of oil, which being that part which is moſtly deprived of its acid, does not congeal; then a ſecond oil of a red color paſſes, which congeals when cold, and which becomes more and more thick as the diſtillation advances. Laſtly, a ſmall quantity of charry matter remains in the retort, which in an open fire can be ſcarcely burnt entirely, and reduced to aſhes.

If the congealed oil in the receiver be again diſtilled, more acid and fluid oil are obtained. Thus the whole of it may be reduced into acid and fluid oil by repeated diſtillations.

The acid obtained is accompanied with phlegm, particularly at firſt, and with a portion of oil united with it, which it renders ſoluble in water, and to which it partly owes its volatility. It is owing to this oil that the acid has the empyreumatic ſmell of burnt butter.

There are many eſſential remarks to be made upon this analyſis of butter by diſtillation; becauſe it preſents exactly the ſame phenomena as the analyſis of all other concrete oily matters of the ſame kind, ſuch as wax, ſuet, cacao, butter, ſperma-ceti, and may be conſidered as a ſpecimen of the decompoſition of all theſe matters.

Firſt, it is neceſſary that theſe diſtillations ſhould be made ſlowly, and with the preciſe degree of heat neceſſary for continuing a moderate diſtillation; becauſe when the diſtillation is too much hurried, the acid has not time to ſeparate itſelf, and the concrete oily matter paſſes almoſt entirely into the receiver without ſuffering any decompoſition: but whatever management be employed, a conſiderable part of this half-decompoſed matter always paſſes, which muſt be ſubjected to future diſtillations in order to reduce it to fluid oil.

Secondly, when the diſtillation is too much hurried, the acid paſſes in white ſenſible vapors from the quantity of oil united with it. For the ſame reaſon, towards the end of the diſtillation, when the fire muſt be raiſed, the acid always paſſes in this form of white ſenſible vapors.

Thirdly, at each diſtillation, made of butter, or of its congealed oil, there is always a portion of oil entirely decompoſed; and thus the quantity continually diminiſhes, and ſenſibly.

This quantity of entirely decompoſed oil is proportionable to the quantities of phlegm acid, charry reſiduum, or earthy phlogiſticated matter, which are obtained at each diſtillation, and are the proximate principles of the oil. This remark is applicable to the diſtillation of any oil. *See* Oil.

We ought alſo to obſerve in general upon this analyſis of butter, that this matter, although derived from animal bodies, does not yield a particle of volatile alkali; neither does the fat of animals; which proves that theſe ſubſtances are not aſſimilated to other animal ſubſtances, all which, when decompoſed, furniſh volatile alkali, without excepting the oils obtained from theſe ſubſtances.

Butter is conſtantly uſed in food, from its agreeable taſte; but to be wholeſome, it muſt be very freſh, and free from rancidity, and alſo not fried or burnt; otherwiſe its acrid and even cauſtic acid being diſengaged, diſorders digeſtion, renders it difficult and painful, excites acrid, empyreumatic belchings, and laſtly, introduces much acrimony into the blood. Some perſons have ſo delicate ſtomachs, that they are even affected with theſe inconveniences by freſh butter and by milk. *See* MILK. This obſervation is alſo applicable to oil, to fat, to chocolate, and in general to all oleaginous matters.

CXXV. BUTTER *of* ANTIMONY. Butter of antimony, called by ſome chemiſts the *glacial oil of antimony*, is compoſed of marine acid united with the reguline part of antimony.

This is one of the combinations which cannot be made directly; that is, by the application of pure and liquid marine acid to the regulus of antimony; for in this manner the marine acid, however ſtrong, diſſolves none, or almoſt none, of the regulus: but when the acid is in its higheſt degree of concentration, reduced almoſt to dryneſs, as it is in ſeveral combinations, and when the body to which it is united has a leſs ſtrong affinity to it than the regulus of antimony has, then it quits that body to unite with the regulus, and forms the butter of antimony.

Marine acid united with mercury has all the above-mentioned conditions; wherefore butter of antimony may be made by mixing together corroſive ſublimate and regulus of antimony, both well powdered, and by applying a certain heat and diſtillation.

Lemeri, the moſt exact of the operators who have written, ſays, that the beſt proportion of corroſive ſublimate and regulus of antimony is ſixteen parts of the former to ſix parts of the latter. He obſerves, that this mixture frequently becomes very hot, ſome time after it has been made. This heat proceeds from the re-action of the two matters upon each other even without fire.

To proceed to the diſtillation of butter of antimony: this mixture muſt be put in a retort of convenient ſize, the neck of which ought to be large and ſhort; this retort is to be placed in a furnace with a ſand-bath; a receiver is to be luted, and the diſtillation is to be carried on at firſt by a gentle fire, which is to be encreaſed as more heat becomes neceſſary to continue the operation; a heavy liquor riſes, which congeals in the receiver when it cools: this is the butter of antimony. The operation is ſtopped when it appears that it cannot be continued without a great encreaſe of heat, by which fluid mercury would be diſtilled inſtead of butter of antimony.

If then it be required to obtain this mercury, which is a very pure mercury, revived from corroſive ſublimate, before the fire is encreaſed, it is proper to remove the receiver, and apply another containing ſome water.

It is evident, that as the marine acid only unites with the regulus of antimony by diſengaging itſelf from the mercury of the corroſive ſublimate, this latter metal ought to appear in its proper fluid form; but as it is leſs volatile than the butter of antimony, it does not riſe till this has paſſed, and the fire be encreaſed.

Butter of antimony may alſo be made by uſing antimony itſelf inſtead of its regulus; becauſe the acid of corroſive ſublimate attacks as eaſily the regulus of antimony in the antimony itſelf, although it be there united with ſulphur, as when it is pure: but it is evident, that in this caſe more antimony muſt be uſed, than the requiſite quantity of regulus in the preceding operation. Lemeri obſerves, that twelve parts of antimony are neceſſary for ſixteen parts of corroſive ſublimate.

When butter of antimony is made by this latter method, it more readily congeals, and is more ſolid than when made with the regulus.

Mr. Baron, in his notes on Lemeri's Chemiſtry, ſays, that this proceeds from the greater quantity of acid contained in the butter made with the regulus than in that made with antimony. This matter would require a particular examination.

However this may be, a part of this butter made with antimony always congeals in the neck of the retort, and is frequently accumulated there in ſufficient quantity to block up the paſſage, by which means the confined vapors may occaſion an exploſion. This inconvenience is prevented by applying a hot-coal near the neck of the retort, by which the butter is melted, and made to flow into the receiver.

It is evident, that when the butter of antimony is made with antimony, if the diſtillation be continued after the butter has paſſed, we ſhall not then obtain fluid mercury, but a combination of mercury with the ſulphur of the antimony, that is, a cinnabar will be ſublimed. This is called the *cinnabar of antimony*. *See* MERCURY, SULPHUR, *and* CINNABAR.

This cinnabar makes its appearance towards the end of the operation by red vapors. As ſoon as theſe are ſeen, the receiver ought to be changed.

The butter of antimony made by either of theſe operations, eſpecially by the latter, is generally rendered more or leſs impure by ſome fluid mercury, or by ſome cinnabar, which are raiſed along with it: but it is eaſily purified from theſe extraneous ſubſtances by a ſecond diſtillation with a gentle heat, when it riſes very white and pure. This ſecond diſtillation, as all other repeated diſtillations and ſublimations for the purifying of ſubſtances, is called *rectification*.

Sweet ſublimate, *mercurial panacea*, and *white precipitate*, are alſo mercurial combinations with marine acid; and, like the corroſive ſublimate, are capable of being decompoſed by means of regulus of antimony, and of forming with it kinds of butter of antimony. But Lemeri obſerves, that theſe butters are leſs cauſtic than that made with corroſive ſublimate; undoubtedly becauſe theſe mercurial compounds contain leſs marine acid.

Finally, butter of antimony may be made with *luna cornea*, which is a combination of ſilver with very concentrated marine acid, which is nearly in the ſame ſtate as it is in corroſive ſublimate, (*ſee* LUNA CORNEA); becauſe the marine acid has leſs affinity with ſilver than with regulus of antimony. This butter is called the *lunar butter of antimony*.

Butter of antimony then contains a very concentrated marine acid, which is not ſo intimately engaged with the regulus of antimony as to loſe all its properties; hence we may account for the property which the butter of antimony has of attracting moiſture from air, and for its cauſticity; for it is ſtrongly corroſive, and is applied, like lapis infernalis, to ulcers and to carious bones. *See* CAUSTICITY.

This metallic ſalt has been called *butter*, from its conſiſtence, which is nearly the ſame as that of butter, and from the facility with which it melts with a very gentle heat.

Butter of antimony ought to be claſſed amongſt the ſalts which are at once cryſtallizable and deliqueſcent; for however confuſed the maſs ſeems after diſtillation, it is in fact a heap of very ſmall cryſtals.

By the operation of butter of antimony, and its properties, ſeveral eſſential properties of the marine acid and of regulus of antimony are diſcovered.

Firſt, although the marine acid has a great affinity with this ſemimetal, it cannot diſſolve it, but when highly concentrated. This phenomenon is analogous to thoſe preſented by the marine acid with mercury and with ſilver, to both which it has a great affinity, but which it cannot diſſolve unleſs it be very highly concentrated, or applied to them when their aggregation is broken; as we ſee by the operations of making *white precipitate*, *corroſive ſublimate*, *luna cornea*, and of the *concentrated parting*. See *all theſe words*.

Secondly, the property which the butter of antimony has of not being decompoſed by fire alone, as the metallic ſalts are which contain the vitriolic and nitrous acids, depends on the great adheſion which the marine acid contracts with the regulus of antimony, as it generally does with other metallic matters, and on its property of volatilizing them, or carrying them along with it in diſtillation; which we ſee happens in corroſive ſublimate, luna cornea, ſmoking ſpirit of Libavius, and many other chemical operations, in which the moſt fixed metals are carried off by marine acid.

Thirdly, the butter of antimony is by the affuſion of water changed in its nature, or rather is divided into two parts, one of which is perfectly diſſolved by the water and another part is precipitated, being inſoluble by water. The diſſolved part contains its greateſt poſſible quantity of acid, and the precipitated part contains the leaſt poſſible quantity of acid. This latter part, when well waſhed, is called *mercurius vitæ*, or *powder of algaroth*. *See* Powder *of* Algaroth.

Mr Beaumé pretends, that the powder of algaroth is improperly ſaid to contain the leaſt poſſible quantity of acid, ſince, by a ſufficient lavation, he has been able to deprive it of every veſtige of an acid.

Butter of antimony is ſoluble in nitrous acid; and this ſolution is made with great violence: afterwards, by evaporation of the acids, a white calx of antimony is formed, called *Bezoar mineral*. See *that word*.

CXXVI. BUTTER *of* ARSENIC. Butter of arſenic, called alſo *corroſive oil of arſenic*, is a combination of marine acid with arſenic. This combination is made by a proceſs ſimilar to that of the butter of antimony. According to Lemeri, equal parts of butter of arſenic and corroſive ſublimate ought to be pulveriſed, well mixed, and diſtilled together; by which a butyraceous liquor is obtained ſimilar to butter of antimony in its external appearance.

When the diſtillation cannot be continued without conſiderably encreaſing the fire, the receiver ought to be taken off, and another receiver, in which there is ſome water, adapted to the retort; then, upon raiſing the fire, fluid mercury may be obtained. *See* Butter *of* Antimony.

This experiment ſhews, that the affinity of marine acid to arſenic is greater than to mercury. In this operation the mercury is revived from the corroſive ſublimate.

It is evident that this butter of arſenic muſt be a moſt violent cauſtic. It ought not to be ever uſed, from its poiſonous quality. *See* ARSENIC.

It does not appear that this combination of marine acid with arſenic has been carefully examined by any chemiſt.

CXXVII. BUTTER *of* CACAO. Butter of cacao is an oily, concrete, white matter, of a firmer conſiſtence than butter, or even than ſuet. This ſubſtance is extracted from the kernel of a fruit called *cacao*, with which *chocolate* is made.

As the butter of cacao is a true congealed oil, it cannot be obtained without a heat ſufficient to melt it. The beſt method is to bruiſe the cacao, and to boil it in water. Almoſt all the ſuperabundant and uncombined oil, which this ſubſtance contains, is liquefied, and ſeparated from the parenchyma and extractive part; and as it is lighter, it ſwims on the ſurface of the liquor in which it is left to congeal, that it may more eaſily be taken off. This butter is generally mixed with ſome broken ſolid bits of the cacao fruit, from which it may be purified by melting with a very gentle heat without water, in a pretty deep veſſel, and by keeping it thus melted, long enough for an entire ſeparation of the matters to take place according to the ſpecific gravities. By this method, a very white and pure butter of cacao may be obtained.

This oily concrete ſubſtance has a very mild taſte; it has no aromatic ſmell; it does not riſe in diſtillation without a heat ſuperior to that of boiling water; by diſtillation it is partly decompoſed; laſtly, it does not flame, till it is ſufficiently heated to be reduced into vapors. As theſe are preciſely the properties of mild and fat oils obtained from vegetable and animal matters by expreſſion only, the butter of cacao muſt be undoubtedly ranged in this claſs; and as it is concrete, it is analogous to other concrete oily matters of the ſame nature, ſuch as wax, fat, butter of milk, &c. alſo it preſents the ſame phenomena when decompoſed and attenuated by diſtillation. For the reaſon of this *ſee* BUTTER.

Butter of cacao has quite the ſame medicinal properties as all the mild expreſſed oils. It is emollient and blunting when not rancid; it enters into the compoſition of pomatums. *See* OILS (SWEET EXPRESSED).

CXXVIII. BUTTER *of* WAX. Butter of wax is nothing but half-decompoſed wax; that is, wax deprived of a part of its acid by diſtillation. As this acid is the cauſe of the conſiſtence of the oily part of wax, the reaſon is evident that the butter is ſofter than the wax itſelf. It has a ſtrong ſmell, and, when left expoſed to the air, it does not reſume its conſiſtence, in which it eſſentially differs from reſinous matters. *See* WAX.

CXXIX. BUTTER *of* TIN. *Butter of tin* is a name given by ſome chemiſts to a combination of tin with the concentrated marine acid of corroſive ſublimate.

Tin, as well as the regulus of antimony, has a ſtronger affinity to marine acid than mercury has. If then corroſive ſublimate and tin, reduced to ſmall parts, be mixed together, theſe two ſubſtances will act upon each other even without the application of heat, ſo that in time the mixture becomes moiſt, and attracts the humidity of the air. If theſe ſubſtances be diſtilled together immediately after their mixture, the corroſive ſublimate is much more quickly decompoſed by the tin; the marine acid quits the mercury to unite with the tin, the greateſt part of which it carries off along with it. In this diſtillation a kind of *marine ſalt with baſis of tin* paſſes over. Part of this combination is in form of a liquor which ſmokes continually, even when cold. This is called the *ſmoking ſpirit of Libavius*. Another part is raiſed in a concrete form, which more particularly deſerves the appellation of *butter of tin*, although it ſeems that ſeveral chemiſts give this name indifferently to the liquor or concrete matter, or to both of them at the ſame time. *See* SPIRIT (SMOKING) *of* LIBAVIUS.

CXXX. **BUTTON.** By the word *button* is meant the metal which is collected generally in a roundiſh maſs at the bottom of a crucible after fuſion, or which remains in the cupels after cupellation.

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CXXXI. **CADMIA.** The name of *Cadmia*, or *Calamine*, is given to ſeveral different ſubſtances. What is called the *Cadmia of the furnaces* is a matter which is ſublimed when ores containing zinc, like thoſe of Rammelſberg, are ſmelted. This cadmia conſiſts of the flowers of zinc ſublimed during the fuſion, and adhering to the inner ſurfaces of the walls of furnaces, where they ſuffer a ſemi-fuſion, and therefore acquire ſome ſolidity. So great a quantity of theſe are collected, that they form very thick incruſtations, which muſt be frequently taken off. The name of *Cadmia of furnaces*, has alſo been given to all the ſoots and metallic ſublimates formed by ſmelting in the great, although there certainly are great differences in theſe matters. *See* SMELTING *of* ORES.

Several authors call *Native* or *Foſſil Cadmia*, a ſort of ſtone or mineral, containing zinc, iron, and ſometimes other ſubſtances. It is of a yellow or reddiſh colour, and is alſo called *Calamy*, *Calamine*, or lapis calaminaris. Both this mineral and the *Cadmia of Furnaces* are uſed for the preparation of braſs. *See* BRASS.

Laſtly, ſome chemiſts have given the name of *Foſſil Cadmia* to a mineral containing arſenic, frequently biſmuth, ſilver, and particularly the ſemi-metal, the calx of which being melted with vitrifiable matters, forms a beautiful blue glaſs. This mineral is better known by the name *Cobalt*, which only ought to be given to it, to avoid the confuſion attending the application of the ſame name to different ſubſtances. *See* COBALT.

CXXXII. **CALAMINE.** *See* CADMIA, and ORES *of* ZINC.

CXXXIII. **CALAMUS AROMATICUS** (*n*).

CXXXIV. **CALCINATION.** The calcination of a body is, properly ſpeaking, the expoſing of it to the action of fire, to produce ſome change upon it.

The principal effects of fire in chemical operations are to carry off the volatile principles, and to ſeparate them from the fixed, or to occaſion the combuſtion of inflammable matters. Hence it follows that bodies are calcined either to

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(*n*) CALAMUS AROMATICUS. The root of this plant has an agreeable flavour, and peculiar taſte, both which are cauſed by an eſſential oil, of which two ſcruples were obtained by diſtillation from 16 ounces of the dry root. *Neuman.*

deprive them of ſome volatile principle, or to deſtroy their inflammable principle, and ſometimes for both of theſe purpoſes.

We have examples of the firſt kind of calcination, in expoſing calcareous earths and ſtones to the fire, to convert them into quicklime, which is effected by the entire evaporation of the watery principle contained in this kind of earth. *See* Quicklime.

The calcination of *Gypſum*, of *Alum*, of *Borax*, and of ſeveral other *Salts*, by fire, which deprives them of the water neceſſary for their cryſtallization; the roaſting of minerals, by which the fire carries off the ſulphur, arſenic, and other volatile contents; ought to be referred to the firſt kind of calcination.

We have an example of the ſecond kind of calcination, by expoſing imperfect metals to fire; by which they loſe their inflammable principle, their form, and metallic properties, and are changed into earthy matters called *Metallic Calxes.*

It is neceſſary to obſerve, that this ſecond calcination differs eſſentially from the firſt, as the changes produced by it upon imperfect metals are not effected by evaporation, but by decompoſition and deſtruction of their phlogiſton. It is therefore a *combuſtion*, and not a *volatiliſation* of their inflammable principle.

Hence it follows, that the firſt kind of calcination may ſucceed without the contact of air and in cloſe veſſels, although it is more quick and complete in open veſſels, from a property of air, by which it greatly accelerates the evaporation of volatile bodies. *See* Air. But as the ſecond kind of calcination is a true combuſtion, like that of all inflammable bodies, it requires all the conditions neceſſary for combuſtion. and particularly the free acceſs of air. *See* Combustion *and* Calxes (Metallic).

There are many bodies, in the calcination of which an evaporation of volatile parts happens, and alſo a deſtruction or deprivation of their inflammable principle, although without any ſenſible combuſtion of this latter. Such particularly are all combinations of imperfect metallic matters with vitriolic and nitrous acids: when theſe bodies are expoſed to fire, their acid evaporates, and at the ſame time carries off with it their inflammable principle. We have examples of this kind of calcination in expoſing to fire *Martial Vitriol* and *Bezoard Mineral.*

As vitriolic acid, and ſtill more nitrous acid, deprive the imperfect metals of more or leſs of their phlogiſton even without fire, ſeveral of theſe metals, particularly iron, copper, tin, regulus of antimony, are reduced, after they have been diſſolved in theſe acids, to a ſtate ſimilar to that of calcination with acceſs of air; that is to ſay, they become earths, not poſſeſſed of metallic properties, which they cannot reſume without the addition of phlogiſton. Hence moſt chemiſts conſider acids as capable of calcining theſe metals, and they accordingly call earths of metals which have been dephlogiſticated by acids, without fire, *Calxes.*

Laſtly, nitrous acid, when engaged in a fixed alkali, that is, nitre having the property of inflaming when applied to a combuſtible ſubſtance with a red heat, and of making the phlogiſton of theſe bodies burn, becomes a very powerful agent for the calcination of many ſubſtances, and particularly of imperfect metals and charry matters. *See* Nitre. We have a very good example of this kind of calcination in the preparation of diaphoretic antimony.

This calcination of metals by nitre is effected partly by a dephlogiſtication ſimilar to that by nitrous acid in humid ſolutions, and partly by combuſtion: which does not hinder it from ſucceeding without acceſs of air, and in cloſe veſſels, from the peculiar property of nitre in this reſpect. *See* Nitre.

It is proper to obſerve, that certain preparations of gold and ſilver are improperly called calxes, becauſe they are not truly calcined, no method being known by which they can be deprived of their phlogiſton. *See* Gold, Silver, *and* Metals (perfect).

What is improperly called *Calx of Gold*, is nothing but gold reduced into very fine particles, either by amalgamation with mercury, or by its ſeparation from other ſolvents. Moſt of theſe improper names, found in ſuch numbers in chemiſtry, proceed from the ignorance of ancient chemiſts, and ſtill more of alchemiſts, who all believed, for example, that they had proceſſes for decompoſing and calcining gold. Nothing is more equivocal than the pretended calcinations of perfect metals. We cannot, however, affirm its impoſſibility. Some facts even ſeem to make it probable; ſuch as the deſtruction of gold in the focus of Thirſnhauſen's great lens, an account of which is publiſhed by Homberg in the Memoirs of the Academy of Sciences, and the calcination of gold by long reverberation, in the manner of Iſaacus Hollandus. But if the moſt ſimple and eaſy experiments of chemiſtry require frequent repetition to be ſufficiently eſtabliſhed, certainly theſe, which are exceedingly difficult and laborious, require great attention. *See* Combustion, *for ſome eſſential obſervations regarding the ſecond kind of calcination.*

CXXXV. CALXES *of* METALS. Metalic calxes are earths of metals deprived of their phlogiſton, and conſequently of their metallic properties.

All metallic ſubſtances, excepting gold, ſilver, platina and mercury, are ſuſceptible of being deprived of their inflammable principle by ſeveral methods.

The firſt method is by burning their phlogiſton in open air, and by a calcination, or rather a combuſtion ſimilar to that of all other combuſtible matters. *See* Calcination *and* Combustion.

The ſecond method is by applying to metals acids capable of depriving them of their phlogiſton, ſuch as vitriolic acid, and particularly nitrous acid. This kind of calcination of metals is made in the humid way, and by ſolution. *See* Solution.

The third method is by nitre, with which metallic matters may be detonated. This third method, which is compoſed of the two former, is the moſt efficacious and expeditious. *See* Nitre, *and* Detonation *of* Nitre.

The earths of metals deprived of phlogiſton by any of theſe methods have properties peculiar to each, concerning which the articles of the ſeveral metallic ſubſtances ought to be conſulted; but they alſo have properties general and common to all. Theſe are the following.

Not only calcined metals loſe the characteriſtic properties of metals, but alſo the following changes are effected. The more perfectly metallic matters are calcined, the more they loſe of their fuſibility; ſo that very fuſible ſubſtances, ſuch as tin and regulus of antimony, are rendered by a perfect calcination, (that is, till they become very white) bodies abſolutely infuſible, and which may be claſſed amongſt thoſe that are refractory. Hence it is proved that phlogiſton is the principle of fuſibility of metals.

In proportion as metallic ſubſtances loſe their phlogiſton, they become more fixed. This property is leſs ſenſible in metals, from their fixity, than in ſemi-metals, all which are very volatile when in their metallic ſtate, and the calxes or earths of which become exceedingly fixed, as we ſee very evidently from the example of diaphoretic antimony, which reſiſts the moſt violent fire without the leaſt loſs, and which recovers all its volatility, if it be reſtored to its reguline ſtate by addition of phlogiſton. This proves that phlogiſton is a principle eſſentially volatile, and that it communicates its volatility to certain bodies with which it is combined.

Metallic earths become leſs ſoluble in acids, and particularly in nitrous acid, by being deprived of phlogiſton, as we may perceive from crocus martis when well calcined, from calxes of tin, of regulus of antimony, &c. Hence we are led to conclude, that the ſolubility of metallic ſubſtances by acids, and particularly by nitrous acid, depends on the intervention of phlogiſton: for if calxes be reduced by adding phlogiſton, the metals reſulting from that reduction will then recover their ſolubility.

What we have ſaid concerning the general changes produced by calcination of metallic matters, upon their fuſibility, their fixity, and ſolubility, may alſo be applied to their opacity, their ſpecific gravity, in a word, to all their metallic properties, which are always diminiſhed ſo much more in metallic calxes, as they are more perfectly dephlogiſticated. This ſeems to indicate, that if an entire and perfect calcination of metallic ſuſtances could be effected, they would then have no metallic property, and perhaps they would not ſpecifically differ from each other, and only be one and the ſame kind of earth. This is certain, that when the calcination of metals has been too long continued, their calxes become irreducible, or at leaſt much more difficultly reducible; and this reduction is always made with loſs, ſo that the quantity of metal originally calcined is never again obtained.

Although metallic calxes are eſſentially different from calx of ſtone or quicklime, they have nevertheleſs ſome ſimilar properties, particularly thoſe which relate to fixed and volatile alkalis. Thus, for example, fixed alkalis receive from metallic calxes the ſame cauſticity and properties as from quicklime; and volatile alkali may be ſeparated from ſal ammoniac by metallic calxes, and particularly by minium, as it may by quicklime; and it receives the ſame changes, that is, it becomes more penetrating, is always fluid, and cannot be reduced to a concrete ſtate, when treated with a ſufficient quantity of theſe matters. *See* QUICKLIME.

CXXXVI. CAMOMILE (o).

(o) CAMOMILE. In the cups of the flowers of camomile reſides a ſmall quantity of blue eſſential oil. The flowers contain alſo a ſaline ſubſtance, which being extracted by decoction in wine, precipitated ſilver and mercury from nitrous acid, and theſe precipitates were different from luna cornea and corroſive ſublimate. *Neuman.* Camomile flowers have been found by Dr. Pringle's experiments to poſſeſs eminently an antiſeptic quality.

CXXXVII. CAMPHOR. Camphor is a vegetable, concrete, very volatile ſubſtance, and inflammable, as eſſential oils are; of a ſtrong ſmell, and eaſily ſoluble in ſpirit of wine.

From all theſe properties, camphor perfectly reſembles reſins; but on the other ſide, it eſſentially differs from them in this, that when expoſed to fire in cloſe veſſels, it is entirely ſublimed without ſuffering any decompoſition, and without leaving any reſiduum of coal or other matter. Although it has a ſtrong taſte, it has not the acrimony of eſſential oils: the moſt cauſtic alkalis do not act upon it: the vitriolic and nitrous acids diſſolve it, but without effervеſcence, heat, inflammation, ſcorching, or other ſenſible change, even when theſe acids are concentrated.

Nitrous acid diſſolves camphor without commotion; and the ſolution is clear and limpid. It is called *Oil of Camphor*. When it is mixed with too much water, the mixture becomes turbid and milky, becauſe the acid has a ſtronger affinity with water than with camphor. The camphor then quits the acid, and appears in white flocks, which ſoon precipitate to the bottom of the containing veſſel, their weight being encreaſed by ſome adhering acid. But when this acid is taken off by the water, the flocks of camphor riſe to the ſurface, and there float. When they are compleatly waſhed and dried, they are found to be camphor entirely ſimilar to what it was before this ſolution and precipitation. This is a manifeſt proof that camphor receives no change from the nitrous acid; which, however, of all acids, acts the moſt powerfully upon oily matters. *See* OILS (ESSENTIAL) *and* RESINS, *for the reſemblances and differences betwixt camphor and theſe ſubſtances.*

It follows from what has been ſaid concerning the properties of camphor, that this ſingular ſubſtance, although it has many of the eſſential properties of oils and reſins, is not, however, comparable to any of thoſe which are known, and forms a claſs apart. As, excepting its concrete ſtate, camphor approaches more to the nature of ether, preciſely by thoſe very properties in which it differs from oils, it is to be preſumed that this ſubſtance is analogous to ether, as Mr. Macquer conjectures in his Elements of Chemiſtry. *See* ETHER.

All the camphor which is ſold comes from India and Japan. It is procured from a kind of laurel called *Laurus Camphorifera*, great numbers of which grow in the iſland Borneo. A long time this tree was believed to be the only vegetable containing camphor; but ſeveral modern chemiſts, and particularly Mr. Cartheuſer, have diſcovered, that many aromatic plants, as thyme, roſemary, ſage, and almoſt all the labiated kind, contain a ſubſtance of the nature of camphor, which may be extracted, although in very ſmall quantities.

Camphor when firſt extracted from its tree is mixed with many impurities, and is then called *Rough Camphor*. The Dutch, who chiefly make a trade of it, purify it by ſublimation in glaſs matraſſes.

Camphor is uſed in medicine as ſedative and antiſpaſmodic. It ſucceeds well in many convulſions, and other nervous affections. This quality is common to it, and to all other ethereal, oily, volatile ſubſtances, ſuch as *Ether, Dippel's Animal oil, highly rectified Eſſential Oils; Muſk, Caſtor, Opium*, and other ſimilar ſubſtances. Hoffman has obſerved and commended, more than any other phyſician, the ſedative powers of camphor. This ſubſtance is alſo very ſucceſsfully uſed as a powerful antiſeptic; and when diſſolved in ſpirit of wine, is employed againſt gangrenes.

CXXXVIII. CANTHARIDES (p).

CXXXIX. CAP. The piece which terminates the top of a melting furnace is called the *Cap*. This piece has the form of an oblong dome. In one ſide there is a large oval door, intended for the introduction of a conſiderable quantity of coal at a time, becauſe this kind of furnace conſumes a great deal, and muſt be quickly ſupplied. The upper part of the cap is terminated by a tube or chimney, which may be lengthened at pleaſure by the addition of other tubes adjuſted to each other. *See* FURNACE (MELTING).

CXL. CAPITAL. The *Capital* or *Head* is the upper part of an alembic. *See* ALEMBIC.

CXLI. CAPUT MORTUUM. This is a Latin name given to fixed and exhauſted reſiduums remaining in retorts after diſtillations.

As theſe reſiduums are very different, according to the ſubſtances diſtilled, and the degree of heat employed, they ought to be ſpecified more particularly by adding a term denoting their qualities; as, for example, we might ſay, *Earthy Reſiduum*, *Charry Reſiduum*, *Saline Reſiduum*, &c. This method is more accurate and diſtinct, and is chiefly uſed by modern chemiſts.

CXLII. CARDAMOM (q).

CXLIII. CARDUUS. (r).

CXLIV. CARMINE (s).

CXLV. CARNELIAN (t).

CXLVI. CASE-HARDENING (u).

(p) CANTHARIDES. Theſe inſects contain a very acrid reſinous ſubſtance, ſix drams and two ſcruples of which were extracted by ſpirit of wine from four ounces of cantharides. The ſtimulating power of cantharides is cauſed by this ſubſtance, and not, as ſome imagine, by a volatile alkali, of which they yield leſs by analyſis than ſome other animal ſubſtances, and none without the action of fire. *Neuman*.

(q) CARDAMOM. An ounce of the ſeeds of the leſſer cardamom contain about a ſcruple of eſſential oil, by which their pungency and aromatic ſmell are cauſed, with fourteen grains of reſinous extract, and forty-five grains of mucilage. *Neuman*.

(r) CARDUUS BENEDICTUS. From four ounces of the leaves of this plant may be obtained about 4½ drams of reſinous extract by means of ſpirit of wine; or from the ſame quantity of leaves about 6½ of mucilaginous extract by means of water. In the juice of this plant, after proper depuration and evaporation, ſaline cryſtals ſimilar to nitre are formed. *Neuman*.

(s) CARMINE is a fine pigment prepared by diſſolving cochineal in an alkaline lixivium, and precipitating the ſolution by alum. It conſiſts, therefore, of the coloring matter of cochineal adhering to the earth of alum.

(t) CARNELIAN, *Carneolus*, or *Sardus*, is a ſemi-tranſparent reddiſh agate. *See* AGATE.

(u) CASE-HARDENING of iron is a ſuperficial converſion of that metal into ſteel by the ordinary method of converſion, namely, by cementation with vegetable or animal coals. This operation is generally practiſed upon ſmall pieces of iron wrought into tools, and inſtruments, to which a ſuperficial converſion is ſufficient; and it may be performed conveniently by putting the pieces of iron to be caſe-hardened, together with the cement, in an iron box, which is to be cloſely ſhut and expoſed to a red heat during ſome hours. By this cementation, a certain thickneſs from the ſurface of the iron will be converted into ſteel, and a proper hardneſs may be afterwards given by ſudden extinction of the heated pieces of converted iron in a cold fluid. *See* STEEL.

CXLVII. CASSIA (x).

CXLVIII. CASTOR (y).

CXLIX. CAUSTIC (COMMON). Common cauſtic is a fixed alkaline ſalt, ſharpened by quick-lime, and deprived of all moiſture by drying and fuſion. The alkali employed for this preparation is generally potaſh. A lixivium is made with quick-lime, like that of the ſoap-boilers, called ſoap-leys. *See* LIXIVIUM *of* SOAP BOILERS. This lixivium is to be evaporated to dryneſs in a copper or ſilver veſſel. Afterwards the dry matter is to be put into a crucible, and expoſed to fire till it flow like melted wax. Then it is to be poured into a baſon, and quickly cut into pieces, while it is ſtill hot and moiſt, and is to be ſpeedily put into a glaſs bottle, well cloſed with a glaſs ſtopper.

An alkali thus treated is much more cauſtic than ordinary fixed alkali. It is alſo more fuſible; and attracts the moiſture of the air much more readily; for which reaſon it ought to be cut and put into bottles, while it is yet hot, otherwiſe it would become very ſoon moiſt.

This alkali when applied to the ſkin during half or three quarters of an hour, corrodes it, and forms a painful eſchar, like that produced by burning. It is employed to open iſſues, which formerly were much uſed, but were afterwards almoſt aboliſhed. They have ſince been brought again into frequent uſe; and juſtly, for they are ſerviceable by evacuating vicious fluids which reſiſt other remedies. But at preſent common cauſtic is not much uſed for the opening of iſſues, becauſe it occaſions a quick and long pain. The common method at preſent is to make an inciſion with a knife, and to promote the ſuppuration by methods well known in ſurgery.

The cauſticity of common cauſtic muſt not be believed to proceed from a perfect drying and concentration of the alkali. This concentration does indeed augment its cauſticity; but we are no leſs certain, that independantly of that, alkalis treated with quick-lime are much more active and cauſtic, even when they are fluid, than any other alkalis. This is evident from the effects of the lixivium, or ley of ſoap-boilers, which almoſt inſtantaneouſly corrodes and deſtroys all animal matters. This cauſticity then is cauſed by ſome particular change produced upon alkalis fixed or volatile by quick-lime; which change probably conſiſts in depriving them of ſome unctuous matter, which invelops and blunts their ſaline principle. *See* ALKALI (FIXED), ALKALI (VOLATILE), AMMONIAC SALT, SPIRIT (VOLATILE) *of* SAL AMMONIAC, LIXIVIUM *of* SOAP-BOILERS

CL. CAUSTIC (LUNAR). Lunar cauſtic, or *Lapis Infernalis*, is a cauſtic made by taking from lunar cryſtals all their water of cryſtallization by fuſion.

To make the lunar cauſtic, cryſtals of ſilver are to be put into a Heſſian crucible, which ought to be large in proportion to the quantity to be uſed, becauſe a conſiderable ſwelling and frothing happens in the beginning of this fuſion. The crucible is to be placed in a furnace which ought to draw little air, and ſurrounded by a very ſmall quantity of lighted coals, becauſe theſe cryſtals are very fuſible, and too great heat would be prejudicial to the preparation of the lunar cauſtic. This matter is then to be very quickly liquified. In the beginning particularly, the heat ought to be moderate, otherwiſe a part of the matter might flow over the crucible, and deflagrate like nitre upon the coals, by which the ſilver would be reduced. While the ebullition gradually diminiſhes, the fire is to be encreaſed; and when the matter is brought to a perfect and tranquil fuſion, it is to be caſt into an iron mould previouſly heated and greaſed in its inner ſurface. The lunar cauſtic is there to be left till it is fixed and cold, and then it is to be put into a bottle with a glaſs ſtopper. The lunar cauſtic ought to be formed into ſmall cylindrical pieces, like pencils, of about a line in diameter, and the ſurgeon who uſes them puts them in a crayon or pencil caſe, to prevent his fingers being injured by touching them. The mould for the lunar cauſtic is ſo made as to give them that form. It conſiſts of five or ſix hollow cylinders, placed vertically and parallel to each other, to which a gutter is adapted, by means of which the matter is poured into them. This mould is compoſed of two pieces which exactly fit each other, in each of which the ſame number of hollow ſemi-cylinders correſpond to thoſe of the other. By this diſpoſition, when the lunar cauſtic is caſt and cooled, it is obtained in entire cylinders, by ſeparating the two pieces of the mould.

(x) CASSIA. The fruit called *Caſſia Fiſtularis* contains a ſweet ſaline ſubſtance, ſoluble in water or in ſpirit of wine. *Neuman.*

(y) CASTOR. Two drams and a ſcruple of extract may be obtained from an ounce of caſtor by ſpirit of wine, or by water. By diſtillation with water, the peculiar ſmell of the caſtor is given to the water; whence we may probably infer that it contains an eſſential oil. By diſtillation with ſpirit of wine, none of this peculiar ſmell is given to the ſpirit. *Neuman.*

The lunar cauſtic muſt be poured as ſoon as it is in tranquil fuſion, for that degree of heat is ſufficient to carry off its acid, which may be obſerved to diſſipate in fumes; and conſequently, if it was left in the fire long after it is thus fuſed, it would loſe ſome of its cauſticity, which it entirely owes to this acid.

The operation for lunar cauſtic ſhews two remarkable phenomena. The firſt is the black color aſſumed by the cryſtals of ſilver thus fuſed. I believe this color proceeds from a part of the phlogiſton of the nitrous acid, which attaches itſelf to the ſilver ſuperficially, and which always gives a black color to this and other white metals, ſuch as mercury, lead, and biſmuth, when it is thus united to them.

The other remarkable phenomenon is a certain ſymmetry of arrangement, or cryſtallization, which lunar cauſtic takes when it cools and becomes ſolid. If a pencil of lunar cauſtic be broken into pieces, its inner ſubſtance may be obſerved to be compoſed of needles or radii paſſing from the circumference to the center, much like the inſide of the round ferruginous and ſulphureous pyrites. This phenomenon is common to all bodies of a certain degree of ſimplicity of compoſition, which paſs without agitation from a liquid to a ſolid ſtate, and is a ſpecies of cryſtalliʒation. Perhaps the ſame phenomenon occurs in many other neutral ſalts in which it has not yet been remarked. *See* CRYSTALLIZATION.

Lunar cauſtic ought to be made with teſted ſilver. If ſilver allayed with copper be uſed, the cryſtals of ſilver ought to be well drained upon brown paper, by which they will be freed from the ſolution of copper, and will become white. This ſolution of copper in nitrous acid when dried is alſo cauſtic, but leſs ſo than lunar cauſtic. It alſo has the inconvenience of becoming moiſt in the air. *See* SILVER, CAUSTICITY, *and* CRYSTALS *of* SILVER.

CI.I.

CLI. CAUSTICITY. By this word is denoted a quality belonging to ſeveral ſubſtances, by the acrimony of which the parts of living animals may be corroded, and deſtroyed. Bodies which have this quality, when taken internally are true poiſons. The cauſticity of ſome of theſe, as of *arſenic*, is ſo deadly, that even their external uſe is proſcribed by prudent phyſicians. Several others, as *nitrous acid*, *lapis infernalis*, or *lunar cauſtic*, *common cauſtic*, *butter of antimony*, are daily and ſucceſsfully uſed to conſume excreſcences, to deſtroy fungous fleſh, to open iſſues, &c. They ſucceed very well when properly employed, and ſkilfully managed.

The cauſticity of bodies depends entirely on the ſtate of the ſaline, and chiefly of the acid matters which they contain. When theſe acids happen to be at the ſame time much concentrated, and ſlightly attached to the matters with which they are combined, they are then capable of acting, and are corroſive and cauſtic. Thus fixed and volatile alkalis, although they are themſelves cauſtic, become much more ſo by being treated with quicklime, becauſe this ſubſtance deprives them of much fat or inflammable matter, which binds and reſtrains the action of their ſaline principle. (z) By this treatment then, the ſaline principle is more diſengaged, and rendered more capable of action. Alſo, all combinations of metallic matters with acids, form ſalts more or leſs corroſive, becauſe theſe acids are deprived of all their ſuperabundant water, and are beſides but imperfectly ſaturated by the metallic matters.

Nevertheleſs, ſome other circumſtance is neceſſary to conſtitute the cauſticity of theſe ſaline metallic matters. For the ſame quantity of marine acid, which when pure and diluted with a certain quantity of water ſhould be incapable of producing any harm, ſhall however produce all the effects of a corroſive poiſon when it is united with mercury in *corroſive ſublimate*, although this ſublimate ſhall be diſſolved in ſo much water, that its cauſticity cannot be attributed to the concentration of its acid.

This effect is attributed by ſome chemiſts to the great weight of the metallic parts with which the acid is united. This opinion is very probable, ſince the cauſticity is nothing but its diſſolving power, or its diſpoſition to combine with other bodies ; and this diſpoſition is nothing elſe than attraction, which is one and the ſame thing as weight or gravitation.

CLII. CAWK. (a)

CLIII. CEMENT. All thoſe powders and paſtes are called *cements*, with which any body is ſurrounded in pots or crucibles, and which are capable, by help of fire, of producing changes upon that body. Hence the expreſſions *to cement*, and *cementation*.

The principal cements are the *royal cement*, which is uſed to ſeparate ſilver from gold in the operation called *Concentrated Parting*; See PARTING

(z) The ſubſtance which quick-lime takes from alkaline ſalts, by which the diſſolving power of theſe ſalts is encreaſed, is fixable air. *See* AIR (FIXABLE).

(a) CAWK is a white, very denſe, ſparry ſubſtance, unſoluble in acids, and fuſible by fire. It is generally found in or near lead-mines. If an ounce or two ounces of cawk be thrown red-hot upon fifteen ounces of melted antimony, and the fuſion continued about two minutes, a regulus weighing fifteen ounces will be obtained, hard and white. *See Phil. Tranſ. Numb.* [illegible] This experiment Dr. Lewis has frequently repeated with ſucceſs.

TRATED) the cement for converting iron into ſteel (*ſee* STEEL); the cement for converting certain glaſs into porcelain (*ſee* GLASS *and* PORCELAIN); the cement for converting copper into braſs; *ſee* BRASS.

Cements may be made of many various kinds, and for various purpoſes, by varying the materials of the compoſitions. Cementation is generally a very powerful method of producing changes upon bodies, or of forming combinations which could not otherwiſe be eaſily effected; becauſe in this operation the active matters of the cement are in a ſtate of dryneſs, are reduced into vapors, and aſſiſted by conſiderable heat.

CLIV. CEMENT-COPPER. (b)

CLV. CENTAURY. (c)

CLVI. CERUSS, or WHITE LEAD. Ceruſs is a kind of ruſt of lead which has been corroded and half-diſſolved by vapors of vinegar. To make ceruſs, leaden plates rolled ſpirally, ſo that the ſpace of an inch ſhall be left betwixt each circumvolution, muſt be placed vertically in earthen pots of a proper ſize, containing ſome good vinegar. Theſe leaden rolls ought to be ſo ſupported in the pots, that they do not touch the vinegar, but that the vapor of this acid may circulate freely betwixt the circumvolutions: theſe pots are to be covered, and placed in a bed of dung, or in a ſand-bath, by which a gentle heat may be applied. The acid of vinegar, which very well diſſolves lead, being thus reduced into vapors, eaſily attaches itſelf to the ſurface of theſe plates, penetrates them, and is impregnated with this metal, which it reduces to a beautiful white powder called *Ceruſs*: when a ſufficient quantity of it is collected on the ſurface of the plates, the rolls are taken out of the pots, and unfolded; the ceruſs is then taken off, and they are again rolled up, that the operation may be repeated.

This management is very ingenious; becauſe the plates of lead thus diſpoſed preſent the greateſt ſurface to the vapors of vinegar, while they occupy the leaſt poſſible ſpace.

As in this operation the acid of vinegar is overcharged with lead, this metal thus changed into ceruſs, is not properly in a ſaline ſtate; hence ceruſs is not in cryſtals, nor is ſoluble in water: but a ſaline quality would render it unfit for painting, for which it is chiefly employed.

Ceruſs ground and prepared for painting is called *white lead*. It is the only white hitherto found fit for painting in oil. The diſcovery of another white for this purpoſe is deſirable, not only from its faults as a paint, but alſo from its injuring the health of perſons employed in its manufacture, by affecting them with a ſevere diſeaſe, which lead and all its preparations frequently occaſion, called the *colic of minerals*, or the *colic of painters*.

Ceruſs, like the other preparations of lead, is drying, ſedative, and lenient; as ſuch it is employed, but only externally. It is an ingredient in many ointments, plaiſters, and other pharmaceutical preparations deſigned for external maladies.

(b) CEMENT, or ZIMENT COPPER, is copper precipitated from vitriolic waters by iron. The name is derived, as is ſaid, from a vitriolic water in Hungary called ziment.

(c) CENTAURY. The leaves of the leſſer centaury contain a bitter ſubſtance ſoluble by water, or by ſpirit of wine. The green color of the plant reſides in the reſinous part, being extracted by ſpirit of wine, but not by water.

As lead is much divided in ceruſs, and is already penetrated with a certain quantity of acid of vinegar, its ſaturation with this acid may be eaſily compleated, by diſſolving ceruſs in diſtilled vinegar. Thus the lead is entirely reduced to a ſaline ſtate. From this ſaturation a cryſtallizable neutral ſalt with metallic baſis reſults, called *ſugar* or *ſalt of lead*. *See* SUGAR *of* LEAD.

CLVII. CERUSS *of* ANTIMONY. This name is given by ſome chemiſts to a pearl-colored matter, or white earth, which ſeparates from the water with which diaphoretic antimony has been waſhed. It is the fineſt part of the white calx of antimony, which has been diſſolved by the alkali of nitre formed in this operation. The peculiar earth of the alkali, ſome of which always ſeparates after every calcination and ſolution, probably makes a part alſo of the ceruſs of antimony. *See* DIAPHORETIC MINERAL.

CLVIII. CHALK. Chalk is a calcareous earth, found in form of friable ſtones, and therefore cannot be poliſhed as marble and other hard calcareous ſtones may. Chalk is alſo found in powder. This ſubſtance has all the properties which characterize calcareous earths. *See* EARTHS (CALCAREOUS).

CLIX. CHALK (BLACK. (*d*).

CLX. CHARACTERS. Chemical characters are ſigns invented to repreſent the principal ſubſtances and operations in a conciſe manner. Theſe ſigns ought to be underſtood, becauſe they are uſed by many authors, and in tables of affinities. *See the* PLATES.

CLXI. CHEESE. Cheeſe is the mucilaginous or gelatinous part of milk. As the milk of all animals is a true emulſion, the cheeſe or caſeous part of milk is an intermediate ſubſtance by which the oily or butyraceous part of this liquor is divided, and ſuſpended in the ſerous part. Thus cheeſe is in milk what mucilage is in emulſions or milky juices of vegetables; but although it has ſome properties common with mucilages, it differs in other reſpects, particularly in its want of ductility, or its viſcidity, and in its property of coagulating by heat and by acids.

Milk is compoſed of three very different ſubſtances, butter, cheeſe, and whey. Theſe ſubſtances are only well mixed together, but not combined, ſince they are capable of a ſpontaneous ſeparation or analyſis: but this ſeparation is not entire and exact, except it be procured by methods peculiar to each of theſe ſubſtances. *See* BUTTER, MILK, *and* WHEY.

To have cheeſe as pure as is poſſible, freſh milk, after the cream is well taken off, muſt be curdled by runnet, or by cream of tartar; the whey then muſt be well drained from it, and it muſt be frequently waſhed with much pure water.

If it be then expoſed to diſtillation with a graduated heat, at firſt a phlegm ariſes which has a ſlight ſmell of milk or of cheeſe, without any marks of an acid or of an alkaline quality. This phlegm ariſes with the heat of boiling water;

(*d*) CHALK (BLACK); *humus nigra pictoria*; *atramentum fiſſile*. This is a light, earthy, flakey ſubſtance uſed for drawing black lines on paper, and for mixing with oil or water for the uſe of painters. It is calcinable by fire to a reddiſh white earth. It is unſoluble by acids, and ſeems to be a bituminous ſlate. Wallerius ſays, that in Sweden, near Hunneberg, a black earth is found as diffuſible in water as Indian ink.

and when the heat is encreaſed an oily and ſaline ſpirit ariſes. The ſaline part of this ſpirit is generally a volatile alkali. Afterwards a ſmall quantity of empyreumatic oil ariſes, which is at firſt fluid, and becomes more and more thick and fetid. Concrete volatile alkali alſo ariſes in this diſtillation; and at length when the retort is very red-hot, and nothing more riſes, a conſiderable quantity of coal remains. This coal is of that kind which cannot be burnt without very great difficulty.

From this analyſis of cheeſe, which reſembles the analyſis of all animal matters, this ſubſtance appears to be the moſt animaliſed part of the milk; for butter and whey furniſh other principles, and particularly much acid. We muſt, however, obſerve, that cheeſe made of the milk of frugivorous animals may furniſh acid, inſtead of volatile alkali. This difference depends perhaps on the nature of the aliments uſed by the animals from which the milk is taken, and alſo of their temperaments, diſpoſitions, and nature of their digeſtions; for, in general, the ſtate of the acid, and its greater or leſs diſpoſition to be transformed into volatile alkali, are very variable in the animal kingdom, particularly in thoſe animals which live only on vegetables, and in their milk, which ſtill more approaches a vegetable nature.

This matter, although very intereſting, has been much neglected by chemiſts. We find, in the Elements of Practical Chemiſtry, an analyſis of cheeſe produced from cows milk, and in that analyſis no mention is made but of an acid, which ſhews the variations that may happen in this matter. We wiſh it were examined as accurately as it deſerves; but for this purpoſe many experiments which require much time and favorable circumſtances ought to be made; which could not be done without having ſeveral cows of different ages, fed with different herbs and grains, at different periods from their having calved, and at different ſeaſons of the year. *See* MILK.

CLXII. CHEMISTRY. Chemiſtry is a ſcience, the object of which is to diſcover the properties of bodies by analyſis and by combination.

The advantages reſulting from this ſcience are too manifeſt and too numerous to require an enumeration in ſuch a work as this.

CLXIII. CHERT. (e)

CLXIV. CHRYSOLITE. (f)

CLXV. CINNABAR. Cinnabar is of two kinds; one is native, the other is artificial.

(e) CHERT, *or* CHERTZ; *petroſilex ſemi-pellucidus, lapis corneus, hornſtein of the Germans.* Chert is a ſemi-tranſparent ſtone of the ſiliceous kind. *See* its chemical properties under the article EARTH (VITRIFIABLE). It is generally leſs hard and of a coarſer texture, than common flints. Large quantities of chert are found in beds of limeſtone, as flints are found in beds of chalk, with this difference, that flints conſiſt of looſe nodules, and chert often forms large maſſes of the rock. They are uſed as grinding ſtones for grinding calcined flints, and other hard ſubſtances, but have too ſmooth and cloſe a texture for the grinding of corn.

(f) CHRYSOLITE is a pellucid, yellowiſh-green ſtone or gem, the ſixth in hardneſs from diamonds, yet ſuſceptible of impreſſion from a file. By fire it ſuffers no other change than loſs of color. It is probably a ſpecies or variety of topaz. Its chemical properties *ſee* under the article EARTH (VITRIFIABLE). This gem may be imitated by adding twenty grains of crocus martis to two ounces of cryſtal-glaſs, and ſix ounces of minium.

Native cinnabar is a heavy and brittle mineral, of a very deep red color when it is in a lump, and conſiſts of ſhining, needle-like, parallel ſtriæ.

This mineral is compoſed of mercury and ſulphur, as will be proved when we ſhall relate its analyſis. It is, properly ſpeaking, mercury mineraliſed by ſulphur, or a true ore of mercury.

Cinnabar cannot be attacked in the humid way by any chemical agent. It is volatile; ſo that, when expoſed to fire in cloſe veſſels, it is entirely ſublimed, without ſuffering any decompoſition. The ſublimation may be repeated any number of times without any change upon the ſubſtance.

If cinnabar be expoſed to the action of fire, with acceſs of air, it is decompoſed by the burning of its ſulphur, and then the mercury diſengages itſelf in vapors; but as theſe vapors are not eaſily to be collected, and as many of them would be loſt by this method of decompoſition with acceſs of air, another method is employed of decompoſing cinnabar in cloſe veſſels, by means of ſome ſubſtance to which ſulphur has a greater affinity than to mercury. Many ſubſtances are known to be poſſeſſed of the quality required for this purpoſe.

Fixed alkalis, quicklime, calcareous earths, iron, copper, tin, lead, ſilver, biſmuth, and regulus of antimony, have a greater affinity than mercury has to ſulphur, and conſequently are capable of decompoſing cinnabar. Of theſe ſubſtances iron is found to be the moſt convenient, and is therefore moſt uſed for the decompoſition of ſmall quantities of cinnabar. When this decompoſition is to be made, equal parts of filings of iron and cinnabar are to be well mixed together, and put into a retort, which is to be expoſed in a furnace to a naked fire, or in a ſand-bath ſo diſpoſed that a ſufficiently ſtrong heat may be applied; a receiver containing water is to be adapted to the retort, and the diſtillation to be promoted. The mercury diſengaged from the ſulphur by means of iron is raiſed into vapors, moſt of which are condenſed in the receiver, at the bottom of which, under the water, they appear changed into fluid mercury; a ſmall part of the mercury remains much divided, and floats on the ſurface of the water in form of a black powder, which muſt be carefully collected, and mixed with the maſs of fluid mercury, with which it eaſily incorporates; this mercury, which is then to be ſtrained through cloſely woven linen, is very pure. It is called *mercury revivified from cinnabar*; and this reduction is called *revivification of mercury from cinnabar*. In the retort is found a maſs compoſed of the iron employed, and of the ſulphur of the cinnabar; or if, inſtead of iron, ſome other ſubſtance was employed, it would be found after the operation united with the ſulphur. Thus if an alkali or calcareous earth has been employed, an earthy or alkaline liver of ſulphur will be found. *See* SULPHUR.

By weighing the cinnabar employed in this proceſs, and the mercury obtained by it, this mercury is found to be ſeven-eighths of the whole cinnabar. Thus in cinnabar ſeven parts of mercury are united with one part of ſulphur.

From a knowledge of the conſtituent parts of cinnabar we may learn a method of compoſing an artificial cinnabar entirely ſimilar to the natural. For this purpoſe, mercury and ſulphur muſt be fuſed and triturated together till they unite well, and form a black body called *Ethiops mineral*. *See* ETHIOPS MINERAL. This Ethiops mineral is then to be ſublimed; but we muſt obſerve, that the operation is attended with ſome difficulties, ſo that a beautiful and perfect cinnabar, in which the mercury and ſulphur are exactly proportioned, cannot be obtained by the firſt ſublimation. The firſt ſublimate is always overcharged with ſulphur, which gives it a black color. The reaſon of this is, that more ſulphur is neceſſarily employed to make the ethiops mineral than is ſufficient to form cinnabar: but by each ſubſequent ſublimation ſome of that ſuperfluous ſulphur is ſeparated, till at length, by five or ſix ſublimations, it becomes entirely ſimilar to native cinnabar. (g)

CLXVI. CINNABAR *of* ANTIMONY. An artificial cinnabar may alſo be obtained from the decompoſition of corroſive ſublimate by antimony. This operation is performed by mixing together and diſtilling theſe two compound ſubſtances. The marine acid of corroſive ſublimate, which has a ſtronger affinity to regulus of antimony than to mercury, quits this latter ſubſtance to combine with the former, with which it forms a new compound called *butter of antimony*, that paſſes by diſtillation into the receiver. *See* BUTTER *of* ANTIMONY.

Alſo the mercury of the corroſive ſublimate, being diſengaged from its marine acid, unites with the ſulphur of the antimony likewiſe diſengaged from its regulus; and theſe two ſubſtances, thus united, are ſublimed in form of cinnabar after the butter of antimony has been diſtilled: but although in this proceſs the mercury is not previouſly united with the ſulphur into an ethiops, the ſame ſuperfluity of ſulphur is perceived in the cinnabar produced by this as by the former operation; becauſe the quantity of antimony neceſſarily employed for the compleat decompoſition of corroſive ſublimate, contains more than the requiſite quantity of ſulphur for the formation of perfect cinnabar with the quantity of mercury contained in the corroſive ſublimate. This inconvenience is to be remedied by the method directed in the former proceſs; that is, by repeating the ſublimation till the cinnabar becomes perfect, and entirely ſimilar to the native. It is called *cinnabar of antimony*, becauſe its ſulphur has been furniſhed by antimony.

The chief uſe of cinnabar is for painting. Although this body be compoſed of ſulphur, the color of which is a light citron, and of mercury which is white as ſilver, it is nevertheleſs of an exceeding ſtrong red color. Lumps of it are of a deep brown red, without brilliancy. But when the too great intenſity of its color is diminiſhed by bruiſing it and dividing it into ſmall parts, (which is a method generally uſed to leſſen the intenſity of all colors) the red of the cinnabar becomes more and more exalted, flame-colored, and exceedingly vivid and brilliant. In this ſtate cinnabar is called *vermilion*.

Cinnabar is often employed as an internal medicine. Hoffman greatly recommends it as a ſedative and antiſpaſmodic; and Stahl makes it an ingredient in his *temperant powder*. Other very intelligent phyſicians, and particularly Mr. Cartheuſer, deny that cinnabar taken internally has any medicinal quality. Their opinion is grounded on the unſolubility of cinnabar by any menſtruum. This queſtion concerning the utility of cinnabar taken internally cannot be decided without new reſearches and experiments. But cinnabar is certainly uſed ſucceſsfully to procure a mercurial fumigation, when that method of cure is proper in venereal diſeaſes. For this purpoſe cinnabar is burnt in an open fire on red-hot coals, by which the mercury is diſengaged, and forms vapors, which being applied to the body of the diſeaſed perſon, penetrate through the pores of the ſkin, and produce effects ſimilar to thoſe of mercury adminiſtered by friction.

(g) Hoffman ſays that cinnabar may be produced without ſublimation, by ſhaking or digeſting a little mercury with volatile tincture of ſulphur, by which means the mercury imbibes the ſulphur from the volatile ſpirit, and forms with it a deep red powder, the color of which is not inferior to that of ordinary cinnabar.

When fumigations of cinnabar are applied, the patient ought not to be expoſed to breathe the vapors of the mercury and of the burning ſulphur, which might injure him. *See* Mercury *and* Sulphur. (*h*)

CLXVII. CINNAMON. (*i*)

CLXVIII. CIVET. (*k*)

CLXIX. CLAY, *or* ARGILLACEOUS EARTH, is a particular kind of ſtrong earth, conſiderable banks of which are found almoſt every where, at greater or leſs depths. The general properties and characteriſtics of pure clay are:

1. This earth makes no ſenſible effervelcence with acids, although it be capable of ſolution by acids, as we ſhall ſee.

2. Clay being moiſtened with water, imbibes ſome of that liquid, ſwells, and mixes with it.

3. When it is mixed with no more than the neceſſary quantity of water to reduce it to a moderately ſoft paſte, it is ſo ductile as to be capable of being worked upon a potter's wheel, and of being formed in moulds. By theſe means veſſels may be made of it which keep their form.

4. Clay is denſe, compact, and cloſe. When its ſurface is rubbed with a poliſhed body, it alſo becomes poliſhed.

5. If it be expoſed when moiſt to a gentle heat, it gradually dries and contracts; that is, its dimenſions become leſs; hence it is very apt to crack. (*l*) It retains moiſture pretty ſtrongly, and difficultly allows the laſt portions of it to eſcape.

6. If clay be heated much, and quickly, before it be perfectly dried, it burſts with loud noiſe from the effort made by the water rarefied and changed into vapor, to eſcape from the parts of this tenacious earth which invelop it. Thus this burſting and cracking do not happen, if the clay expoſed to heat contain water enough to render it ſoft; becauſe then the water finding much leſs reſiſtance from the clay, only ſeparates the argillaceous parts from each other, and eſcapes with conſiderable intumeſcence.

(*h*) Some native cinnabars, according to Bruckman, (*Epiſtol. Itiner.*) are ſo hard, that they are poliſhed, turned in a lathe, and wrought like marble.

(*i*) Cinnamon. From 16 oz. of the beſt cinnamon ſcarcely more than two ſcruples and a half of eſſential oil can be obtained. This oil may be raiſed by diſtillation with water, but ſcarcely with ſpirit of wine. The whole taſte and flavor of cinnamon may be extracted by digeſtion with ſpirit of wine. *Neuman.*

(*k*) Civet is an odoriferous unctuous animal juice, ſoluble in oils, but not in ſpirit of wine, nor in water, even by means of ſugar. *Neuman.*

(*l*) Dr. Lewis found from experiments, that pure clay ſoftened with water to a due conſiſtence to be worked upon a potter's wheel, contracted by drying $\frac{1}{20}$th part of every dimenſion.

7. If pure clay, previouſly well dried, be expoſed to a very violent fire, ſuch for example, as the fire of a glaſs-houſe, it does not melt, and reſiſts much more than ſand does the action of fluxes and vitrifying matters. By fire its parts are only very ſtrongly agglutinated; and the maſs of clay thus calcined is called *baked clay*. During this baking it contracts in every dimenſion, and becomes as hard as flint, ſo that it is capable of ſtriking fire with ſteel.

8. When clay has been thus baked by fire, it becomes no longer penetrable by water. If it be ground and levigated, it mixes with water as very fine ſand does; that is, it does not form, as the crude clay does, a tenacious, ductile paſte, fit to be turned on a potter's wheel.

9. Clay is entirely ſoluble in acids, and particularly in the vitriolic, with which acid it forms a vitriolic ſalt with an earthy baſis, which is true alum. *See* ALUM.

10. Laſtly, clay, which, when unmixed, perfectly reſiſts the moſt violent fire without ſhewing any tendency to fuſion, being mixed with equal parts of any calcareous or gypſeous earth, and with two parts and a half, or three parts of any ſand or vitrifiable ſtone, now becomes fuſible, and diſpoſes the other two earths to fuſion.

All the properties which we have enumerated are eſſential to argillaceous earth, when perfectly pure; that is, when free from any mixture of heterogeneous matter. Clay ſo perfectly pure has never yet been found in the earth.

Mr. Macquer, in his Memoir upon clays given to the Academy in the year 1762, from which Memoir the greateſt part of the preſent article is taken, obſerves, that clay being an earth miſcible with water, is liable to mixture with many other matters, and that from this cauſe we never find pure clay, which ought eminently and excluſively to poſſeſs the argillaceous properties, and which ought to be always the ſame, without any peculiar differences; and laſtly, that the only certain method of procuring this earth is to extract it from native clays, or from other bodies which contain it, by means of vitriolic acid, with which it forms alum; and then to decompoſe this alum by phlogiſton or alkalis, which diſengage the vitriolic acid; therefore, properly ſpeaking, earth of alum well prepared can be conſidered as the only pure clay. Further, this earth has ſo ſtrong affinity with phlogiſton, that we cannot expect to obtain it perfectly free from this principle. The general properties of clay, deſcribed above, are then ſolely applicable to this kind of earth. *See the word* ALUM.

Native clays poſſeſs more or leſs of theſe properties in proportion as they are leſs or more altered by mixture of heterogeneous matters.

As clays are very uſeful in chemiſtry, in arts, and in many purpoſes of ordinary life, we ſhall mention ſome important parts of knowledge concerning them; as, the methods of diſcovering their purity, the places where they may be found, and the means of purifying them.

The purity of clays is known by the general properties above related. The more any native clay poſſeſſes of theſe properties, the purer it is.

The ſubſtances which hurt the purity of native clays are ſand, phlogiſton, bituminous matters, vitriolic acid, metallic earths, pyritous matters, calcareous earths, and mica.

Inflammable matters alter the color of clay, which when pure ought to be white. Its color is affected alſo by colored metallic earths, particularly by thoſe of copper and iron, and by all pyritous matters.

Clay, which is colored only by an inflammable matter which is not metallic, loſes its color by fire with acceſs of air, and becomes white. Of this kind are moſt grey and brown clays, of an uniform color, and not veined.

Clays colored by pyritous matters, or by earths of iron or copper, are not rendered white by fire, till they are perfectly deprived of theſe metallic earths. A certain quantity of theſe heterogeneous ſubſtances in clay render it fuſible. Such clays are known by their colors, which are yellow, red, green, or veined, and marbled with ſeveral of theſe colors. They are the moſt unfit of all clays for the making of utenſils intended to ſuſtain intenſe heat, ſuch as chemical veſſels, and the bricks, crucibles, or pots uſed in glaſs-houſes.

We may obſerve, that even the pureſt native clays are never entirely free from a mixture of ſome parts of metallic, particularly ferruginous earth. Mr. Macquer, who has examined above eight hundred clays, ſays, in the above quoted Memoir, that in all that number he did not find one, even amongſt the whiteſt, that was entirely pure and free from metallic matter: but when a very ſmall quantity only of ferruginous earth is in clays; when it is not uniformly mixed with them through all their maſs, which is known by a beautiful and pure white color, but is diſperſed in ſmall yellow ſpots, as it frequently is; then ſuch clays ought to be conſidered as being of a very good quality. The only practical method of ſeparating theſe ferruginous parts, is to break the clay into ſmall lumps, and to cut out the yellow ſpots. This ought to be done before the clay is mixed with water; becauſe by waſhing the ferruginous parts are not ſeparable, but are more intimately mixed with the purer part of the clay.

Pyritous matters, mica, and coarſe ſand mixed with clays render them brittle, and diminiſh their ductility. Clays are eaſily cleanſed from the greateſt part of theſe heterogeneous ſubſtances by waſhing; that is, by mixing the clay well with much pure water, which is left to reſt till only the fineſt and lighteſt parts of the clay remain ſuſpended in the water, the groſſer parts having ſubſided to the bottom: the water then is to be decanted off from the groſs ſediment, and paſſed through a fine ſilken ſearce: the ſediment which is depoſited from this decanted and ſifted water is the fineſt and pureſt part of the clay, and ought to be carefully and cleanly collected and dried. This purification of clay by waſhing is very neceſſary when good pottery or porcelain is to be made. *See* POTTERY *and* PORCELAIN.

The pyritous particles found in clays render them very fuſible. A bit of pyrites left in clay which is expoſed to a baking fire, always forms a cavity in the clay lined with a black leaden color.

The waſhing with water is an effectual method of ſeparating from clay even the ſmalleſt particles of pyrites; becauſe theſe particles have eſſentially a ſpecific gravity much greater than that of clay. But ſand and mica are not ſo eaſily ſeparated from clay. Mr. Macquer has ſhewn in his Memoir, that the moſt careful waſhing is inſufficient for an entire ſeparation of ſandy particles contained in clays; becauſe every native clay contains a conſiderable quantity of ſandy particles as fine and as light as the clay itſelf.

Mica alſo cannot be ſeparated from clay for the ſame reaſon: but theſe fine particles of ſand and mica, which cannot be ſeparated by waſhing, do not injure works made of the clay, but are rather uſeful by preventing cracks in drying and baking. *See* Pottery.

The particles of calcareous earths which injure the purity of many native clays, are eaſily diſcovered by the effervescence which they make with nitrous acid. This kind of earth cannot be ſeparated from clays by waſhing, from the fineneſs and lightneſs of its parts. Clay containing a certain quantity of calcareous earth is by this mixture rendered fuſible, from the ſandy particles inſeparable from the clay: hence all calcareous clays are improper for making utenſils intended to ſuſtain intenſe heat.

Laſtly, vitriolic acid, which appears to have been combined and diſtributed in a ſingular manner by nature in all clays, may be ſeparated from them by digeſting them in an alkaline liquor, and afterwards by edulcorating this clay with a ſufficient quantity of water: but this purification of clays is not neceſſary for moſt purpoſes to which theſe earths may be applied; becauſe this acid is not injurious. Vitriolic acid mixed with clays renders them capable of decompoſing nitre and common ſalt, and of diſengaging the acids of thoſe ſalts.

Theſe extraneous matters being found naturally mixed with clays either ſingle, or ſeveral together, and in all proportions, occaſion a great variety of native clays. No earth has ſo many different kinds; and undoubtedly from this great variety proceeds the multiplicity of names which are annexed to the ſeveral kinds of clay.

The earths called *boles*, *bolar earths*, and *ſealed earths*, are true clays. Their names have been chiefly applied to thoſe clays which ſtick ſtrongly to the tongue, and alſo to certain clays filled with a large quantiry of ferruginous earth, by which they are uniformly colored red or yellow. Other names are applied to clays from their particular uſes. Such are *fuller's-earth*, *tile-earth*, *brick-earth*, *potter's-clay*, *pipe-clay*, *porcelain-clay*.

The earths called *marles*, as they are capable of dilution in water, have a certain degree of binding quality, effervesce with nitrous acid, are fuſible with an intenſe heat, and appear to be nothing elſe than clays more or leſs ſandy, and mixed with much calcareous earth.

Laſtly, epithets are given to many clays denoting their color, as *white clays*, *grey clays*, *blue clays*, *&c.*

But theſe names communicate little knowledge on the true nature of the ſeveral native clays. A more particular examination by chemical proofs is requiſite to inveſtigate the heterogeneous matters with which different native clays are mixed, the mixture of which alters the purity of ſimple and primary argillaceous earth, to which they owe all they poſſeſs of argillaceous properties; then names might be given which ſhould indicate their color and the heterogeneous matters with which they are mixed, or at leaſt thoſe which prevail moſt. Thus amongſt theſe names we ſhould have *white*, *ſandy*, *micaceous*, *or calcareous clays*; *grey* or *blue pyritous clays*; *red or yellow ferruginous clays*; *black bituminous clays*, &c.

As our intention in this work is not to enter into the details of natural hiſtory, we ſhall ſay no more upon this ſubject. What we have ſaid concerning the properties of pure clay, and the different ſubſtances which alter its purity, and more or leſs diſguiſe the argillaceous properties of native clays, is ſufficient to give a notion of the light which chemiſtry can throw on natural hiſtory in this and many other inſtances.

In Mr. Gellert's table the ſubſtances capable of acting upon clays are ſet down in the following order: Vitriolic acid, partly (*ſee* an explanation of this word *partly* at the article ALUM), liver of ſulphur, fixed alkali, borax, calx of lead, calx of antimony, gypſeous earth, calcareous earth.

CLXX. CLOVES. (*m*)

CLXXI. CLYSSUS. By the word *clyſſus* are meant the vapors which riſe during the detonation of nitre with any inflammable body. Theſe vapors may be collected and condenſed into a liquor by a proper apparatus of veſſels.

The vapors reſulting from the detonation of nitre with charcoal are called *clyſſus of nitre*. To prepare this clyſſus, an earthen retort muſt be employed capable of ſuſtaining a great heat applied ſuddenly without injury.

This retort, which ought to be tubulated, is to be placed in a furnace, and to it a very large balloon with a ſmall hole is to be adjuſted. When the bottom of the retort has become red-hot, a ſmall quantity, that is, a dram and a half, or two drams, of a mixture of purified nitre and charcoal powder, is to be thrown into the retort through the tubulated part, which muſt be immediately afterwards cloſed; the nitre then detonates, and the vapors are condenſed in the receiver.

Other parcels of the detonating mixture are to be thrown in ſucceſſively with the ſame management, till a ſufficient quantity of liquor is collected in the receiver. If, inſtead of charcoal-powder, ſulphur be employed to detonate with nitre in cloſe veſſels, the liquor obtained is called *clyſſus of ſulphur*; and if antimony be employed to detonate with nitre, the liquor is called *clyſſus of antimony*.

The old chemiſts who have practiſed theſe operations believed, that the liquors thus obtained had particular virtues for alchemical purpoſes. For this reaſon, they made this preparation with great apparatus and trouble. But now, when chemical operations are better underſtood, theſe liquors are believed to have no virtues. The clyſſus of nitre is made in laboratories, not for any uſe to which it can be applied, but to eſtabliſh a theory concerning the nature of nitrous acid, and to prove that this acid is entirely deſtroyed and decompoſed by detonation.

For, when the operation is finiſhed, nothing is found in the retort but the alkali which was the baſis of the nitre; and the liquor contained in the receiver has no acid taſte, does not redden the tincture of turnſol, makes no efferveſcence with alkaline matters, and is truly nothing but water, which is ſometimes ſlightly

(*m*) CLOVES. The pungency of cloves reſides in their reſin, or rather in a combination of reſin with eſſential oil; for the ſpirituous extract is very pungent; but if the oil and the reſin contained in this extract be ſeparated from each other by diſtillation, the oil will be very mild; and any pungency which it does retain proceeds from ſome ſmall portion of adhering reſin, and the remaining reſin will be inſipid. No plant, or part of any plant, contains ſo large a proportion of eſſential oil as cloves do. From ſixteen ounces Neuman obtained by diſtillation two ounces and two drams, and Hoffman obtained from the ſame quantity an ounce and a half. This oil is ſpecifically heavier than water. *Neuman.*

alkaline, becauſe the force of detonation is capable of raiſing ſome ſmall part of the alkali of the nitre.

The clyſſus of ſulphur is acid, becauſe the vitriolic acid of the ſulphur is not decompoſed, as the nitrous is, by combuſtion, but is diſengaged and ſet at liberty by the burning of the phlogiſton of the ſulphur. Beſides, one part of this vitriolic acid when diſengaged acts upon the nitre, forms with its baſis a vitriolated tartar called *Glaſer's ſal polychreſtum*, and diſengages the nitrous acid. This portion of nitrous acid thus diſengaged by the acid of ſulphur, and which is no longer retained and fixed by an alkali, is not capable of inflaming with phlogiſton: wherefore it is not decompoſed, and, together with the vitriolic acid which is not fixed by the alkali of the nitre, makes part of the clyſſus.

The clyſſus of ſulphur appears then to be compoſed, 1. Of a part of the nitrous acid deſtroyed by inflammation with the phlogiſton of the ſulphur: 2. Of another portion of nitrous acid which is not decompoſed, but is diſengaged by the acid of ſulphur: 3. Of all the acid of ſulphur which does not unite with the alkaline baſis of the nitre.

The clyſſus of ſulphur muſt differ conſiderably according to the proportions of nitre and of ſulphur employed. If a little nitre be added to much ſulphur, the clyſſus will be almoſt all pure acid of ſulphur.

An Engliſh chemiſt *, ſome time ago, found a method of obtaining very advantageouſly the vitriolic acid of ſulphur, by burning ſulphur in cloſe veſſels with a ſmall quantity of nitre. This method of decompoſing ſulphur for the extraction of its acid is ſaid to be executed in great, and to be the cauſe of the great reduction of the price of that acid within theſe few years paſt. This is an inſtance of practical utility from a clyſſus; for the vitriolic acid obtained by detonation of nitre in cloſe veſſels is a true clyſſus of ſulphur.

The clyſſus of antimony is ſimilar to that of ſulphur; for the nitre in this operation chiefly detonates with the ſulphur of the antimony: however, the phlogiſton of the metalline part of the antimony contributes alſo to the detonation. Beſides, ſome flowers of antimony are mixed with this clyſſus.

Several neceſſary precautions ought to be taken to make this operation of a clyſſus ſucceed, and to avoid accidents; for the rapidity and violence with which nitre detonates in certain circumſtances may occaſion a ſtrong exploſion and rupture of the veſſels. To prevent theſe accidents, the inflammable matters ought not to be very well mixed with the nitre, becauſe the detonation is proportionably ſtronger and quicker as the mixture has been made more exactly. Alſo, a ſmall quantity only of the mixture ought to be detonated at once, and another quantity ſhould not be added till the detonation of the former be finiſhed. *See* NITRE, DETONATION *of* NITRE, and GUN-POWDER.

CLXXII. COAGULATION. This term is employed by chemiſts to denote certain operations in which fluid bodies become ſolid; for inſtance, the cryſtallization of ſalts. *See* CRYSTALLIZATION.

CLXXIII. COAGULUM. This Latin word is uſed to ſignify curdled concretions formed by the mixture of two liquors, ſuch as the precipitate of ſilver in the formation of *luna cornea*, the *offa Helmontii*, the *miraculum chemicum*, and many others. *See theſe words.*

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* Dr. Ward. *See* SPIRIT *of* SULPHUR.

CLXXIV. COAL. By the word *coal* is meant any ſubſtance containing oil which has been expoſed to fire in cloſe veſſels, ſo that all its volatile principles are expelled, and that it can ſuſtain a red heat without further decompoſition. Coal is a body ſolid, black, very dry, and conſiderably hard.

The ſpecific character of perfect coal is its capacity of burning with acceſs of air, while it becomes red-hot and ſparkles. ſometimes with a ſenſible flame which gives little light, no ſmoke or ſoot capable of blackening white bodies.

Coal is capable of communicating its inflammable principle either to the vitriolic acid, with which it forms ſulphur; or to the nitrous acid contained in nitre, with which it inflames; or to metallic earths, which it reduces into metals. But the phlogiſton cannot paſs from coal to form theſe new combinations without the aſſiſtance of red-heat.

Coal ſeems to be an unalterable compound in every inſtance but theſe mentioned, of burning in open air, and of communicating its phlogiſton to other bodies: for it may be expoſed in cloſe veſſels to the moſt violent and continued fire without ſuffering the leaſt alteration. No diſpoſition to fuſe, nor any diminution of weight can be perceived. It is a ſubſtance exceedingly fixed, and perhaps the moſt refractory which is known.

No change is produced upon coal by air or by water, nor by the moſt powerful menſtruums of chemiſtry, excepting perhaps by particular proceſſes. A trial might be made whether the concentrated mineral acids, or cauſtic alkalis, would not, when aſſiſted by heat, make ſome alteration upon coal in a long time. The younger Mr. Rouelle propoſed as a problem, in the Journal de Medicine for October, 1762, to *diſſolve vegetable coal in the palm of the hand.* Why he propoſed it as a problem we do not know; ſince he adds, that Mr. Wolf has reſolved it, and that this ſolution may be made by liver of ſulphur. He has not explained whether he means the ſolution of all the ſubſtance of the coal, or of its phlogiſton only.

Coal is evidently a reſult of the decompoſition of the compound bodies from which it is obtained. It conſiſts of the greateſt part of the earthy principle of theſe compound bodies, with which a part of the ſaline principles, and ſome of the phlogiſton of the decompoſed oil are fixed and combined very intimately.

Coal can never be formed but by the phlogiſton of a body which has been in an oily ſtate: hence it cannot be formed by ſulphur, phoſphorus, metals, nor by any other ſubſtance the phlogiſton of which is not in an oily ſtate.

Alſo every oily matter treated with fire in cloſe veſſels furniſhes true coal; ſo that whenever a charry reſiduum is left, we may be certain that the ſubſtance employed in the operation contained oil. *See* OIL.

Laſtly, the inflammable principle of coal, although it proceeds from an oil, is certainly not an oil, but is pure phlogiſton; ſince coal added to vitriolic acid can form ſulphur, to phoſphoric acid can form phoſphorus, to metallic earths can form metals, and can detonate with nitre; and ſince oil can produce none of theſe effects, till it has been decompoſed and reduced to the ſtate of coal. *See* SULPHUR, PHOSPHORUS, METALS, NITRE, *and* OIL.

Beſides, the phenomena accompanying the burning of coal are different from thoſe which happen when oily ſubſtances are burnt. The flame of charcoal is not ſo bright as that of oil, and produces no ſmoke or ſoot.

All the phlogiſton of coal is not burnt in open air, particularly when the combuſtion is ſlow. One part of it exhales without decompoſition, and forms a vapor, or an inviſible and inſenſible gas. This vapor, or this phlogiſton, diſengaged from coal, is very pernicious. It ſo affects the brain and nerves as to occaſion inſtant death. For this reaſon, to remain in a cloſe place where charcoal or other coal is burnt, is dangerous. Perſons ſtruck by vapor of charcoal are ſtunned, faint, ſuffer a violent head-ach, and fall down ſenſeleſs and motionleſs. If they are yet alive, the beſt method of recovering them is to expoſe them as quickly as is poſſible to open air, and to make them ſwallow vinegar, and breathe its ſteam. Acids, and particularly vinegar, ſeem to have a property of fixing and reſtraining in ſome ſort the action of phlogiſton, and of the vapors of volatile inflammable matters, which produce ſimilar effects on animals. For this reaſon, vinegar diminiſhes the accidents of intoxication occaſioned by ſpirituous liquors and by opium. The vapor which exhales from liver of ſulphur, particularly when a large quantity of it is decompoſed by an acid, and the vapors which exhale from matters undergoing the ſpirituous or putrid fermentation, produce the ſame accidents as the vapors of coal, and are remedied by the ſame means.

Amongſt coals, ſome differences are obſervable, which proceed from the difference of the bodies from which they are made; particularly, ſome coals are more combuſtible than others. This combuſtibility of coals ſeems to depend on the greater or leſs quantity of ſaline principle contained in coal; that is to ſay, that the more it contains of ſaline principle, the more eaſily it decompoſes and burns. For example, coals made of plants and wood, containing much ſaline matter capable of fixing it, the aſhes of which contain much alkaline ſalt, burn vigorouſly and produce much heat; whereas the coals of animal matters, the ſaline principles of which are volatile, and cannot be fixed but in ſmall quantity, and the aſhes of which contain little or no alkaline ſalt, are ſcarcely at all combuſtible. For they not only do not kindle ſo eaſily as charcoal does, nor ever burn alone, but they cannot be reduced to aſhes without very great trouble, even when the moſt effectual methods are uſed to facilitate the combuſtion.

I have kept the coal of bullock's blood very red-hot in a ſhallow crucible, ſurrounded with burning charcoal, ſix hours and more, and ſtirred it conſtantly that it might all be expoſed to the air, but I could not reduce it to white or even grey aſhes. It remained ſtill very black, and full of phlogiſton.

The coals of pure oils, or of concrete oily ſubſtances, and ſoot, which is a kind of coal raiſed during the inflammation of oils, are as difficultly burnt as animal coals. Theſe coals contain very little ſaline matter, and their aſhes furniſh no alkali.

Theſe coals, which are ſo difficultly burnt, are alſo leſs capable of inflaming with nitre than others more combuſtible; and ſome of them even in a great meaſure reſiſt the action of nitre.

The refractory quality of coals is a ſingular property. This property is in ſo great a degree, that they are found to be the fitteſt ſubſtances for ſupporting bodies expoſed to the focus of large burning-glaſſes. Nevertheleſs all coal is compoſed of an earth which is not perfectly refractory, of a ſaline matter which is fuſible and aſſiſts the fuſion of other ſubſtances, and of phlogiſton which is certainly the principle of the fuſibility of metals, as their earths become ſo much more difficult to fuſe as they are more dephlogiſticated. (n)

CLXXV. COAL (FOSSIL). (o)

CLXXVI. COATING. (p)

CLXXVII. COBALT. This name is given by authors to ſeveral different minerals. We ſhall here only talk of that kind of cobalt which contains the metallic matter whoſe calx furniſhes a blue glaſs when vitrified; becauſe the name *cobalt* ought to be confined to this mineral alone, to avoid the uncertainty and confuſion too frequent in names of natural hiſtory and of chemiſtry.

Cobalt is a very heavy mineral, of no determinate figure; of a grey color, more or leſs brilliant; of a fine, compact, cloſe grain, the ſurface of which, when it has been expoſed to the air, is covered with a powder, or eﬄoreſcence of the color of a peach-bloſſom.

(n) To *make charcoal*, or vegetable coal, pieces of wood are ſo diſpoſed as to form a pile, generally conical, which pile is covered with turf to prevent the too free draught of air, by which the wood would be reduced to aſhes and not to coal. The pile is then to be kindled, and the fire is to be continued till all the watery and the more volatile parts of the wood are diſſipated; that is, till no more ſmoke ariſes, at which time the wood is thoroughly red-hot. The external air is then to be totally excluded, by covering the pile with earth, and thus the fire is extinguiſhed.

(o) Coal (Fossil), or Pit-Coal, is a black or brown, laminated, bituminous ſubſtance, not very eaſily inflammable, but which once inflamed, burns longer and more intenſely than any other ſubſtance. Of this ſubſtance three kinds are diſtinguiſhed by authors. The reſiduum of the firſt after combuſtion is black; the reſiduum of the ſecond is ſpongy, and like pounce ſtone; and the reſiduum of the third is whitiſh aſhes. Some foſſil coal, by long expoſure to air, falls into a greyiſh powder, from which alum may be extracted. Foſſil coal by diſtillation yields, 1. a phlegm or water; 2. a very acid liquor; 3. a thin oil like naphtha; 4. a thicker oil, reſembling petroleum, which falls to the bottom of the former, and which riſes with a violent fire; 5. an acid concrete ſalt; 6. an uninflammable earth remains in the retort. Theſe conſtituent parts of foſſil coal are very ſimilar to thoſe of amber and other bitumens. *See* Bitumen. For the exciting of intenſe heats, as of furnaces for ſmelting iron-ore, and for operations where the acid and oily vapors would be detrimental, as the drying of malt, foſſil coals are previouſly charred, or reduced to *coaks*; that is, they are made to undergo an operation ſimilar to that by which charcoal is made. By this operation coals are deprived of their phlegm, their acid liquor, and of greateſt part of their fluid oil. Coaks therefore conſiſt of the two moſt fixed conſtituent parts, the heavy oil and the earth, together with the acid concrete ſalt, which though volatile is detained by the oil and earth.

(p) Coating, or Lorication, is an application of clay, or mixture of clay with ſand or other ſubſtance, to the external or internal ſurfaces of chemical veſſels, to guard them againſt the effects of ſudden heat, or of the corroſive quality of the matter to be contained. Thus glaſs retorts intended to be expoſed to what is called a naked fire, that is, to a fire without interpoſition of a ſand-bath or other ſubſtance, ought to be externally coated, by which means they will not be ſo liable to be cracked by the ſudden application of heat and cold. Retorts may be coated in the following manner: Take of clay and ſand equal parts; make them into a thin paſte, with freſh blood prevented from coagulating by agitation till it be cold, and diluted with water; add to this paſte ſome hair and powdered glaſs; with a bruſh dipt in this maſs beſmear the retort; and when this firſt layer is dry, let the ſame operation be repeated twice or oftener, till the coat applied be about one-third part of an inch thick. For the compoſitions for coating crucibles, furnaces, and other inſtruments made of plate-iron, *ſee* Crucible.

This mineral is not found in many places. Hitherto it ſeems to have been found only in Saxony and in the Pyrenean mountains (*q*). It contains ſeveral ſubſtances mixed and confounded together, and in this reſpect ſome cobalts differ from others. All of them contain ſulphur, much arſenic, and the ſemi-metal the calx of which may be made into blue glaſs, and which Mr. Brandt of the Swediſh Academy calls *Regulus of Cobalt* when it is reduced to its metalline ſtate. Beſides theſe ſubſtances, ſome cobalts contain biſmuth, ſilver, or both of theſe.

Of all theſe matters, the peculiar regulus of cobalt renders this mineral valuable from the fine blue which is manufactured from it, and which [illegible] only blue that can be uſed in vitrification.

Nevertheleſs other ſubſtances are collected from cobalt in the operations practiſed on it, but only ſecondarily, becauſe theſe ſubſtances may be obtained without additional labor or expence. For example, as it is neceſſary in the preparation of the blue to expel the arſenic, this mineral muſt be expoſed to long roaſtings; inſtead of diſſipating the arſenic which riſes in vapors during the torrefaction, it is collected in long crooked chimneys, adapted to the furnaces in which the cobalt is roaſted, and thus is obtained almoſt all the arſenic which is ſold in commerce. *See* ARSENIC.

Likewiſe after the roaſting, when the calx of cobalt is fuſed with vitrifiable matters to make the blue glaſs called *Smalt*, the biſmuth and ſilver may be ſeparated and collected.

(*q*) Cobalt has been found in Cornwall, Scotland, and probably in other parts of Europe. That it is in the eaſtern parts of Aſia, appears from the blue coloring on old oriental porcelain. Probably alſo the mines diſcovered in theſe countries are nearly exhauſted, as conſiderable quantities of zaffre and ſmalt are exported from Europe to China. Beſides the grey or aſh-colored cobalt deſcribed in the text, which is the moſt frequent, other cobalts are found of various colors and textures, mixed with various ſubſtances. Wallerius enumerates ſix ſpecies of cobalts. 1. The *aſh-colored ore*, which is regulus of cobalt mineraliſed by arſenic, conſiſting of ſhining leaden-colored grains. Some ores of this kind are compact, reſembling ſteel, and others are of a looſe texture and friable. 2. The *ſpecular ore* is black, ſhining like a mirror and laminated. This ſpecies is very rare, and is ſuppoſed by Wallerius to be a foliated ſpar, or ſelenites mixed with ore of cobalt. 3. The *vitreous*, or *ſlag-like ore*, is of a blueiſh, ſhining color, compact, or ſpongy. 4. *Cryſtallized ore of cobalt* is a grey, deep-colored ore of cobalt, conſiſting of cluſters of cubical, pyramidal, priſmatic cryſtals. 5. *Flowers of cobalt*, red, yellow, or violet. Theſe flowers ſeem to be formed from ſome of the above deſcribed compact ores, decompoſed by expoſure to moiſt air. This decompoſition is ſimilar to that which happens to ferruginous and cupreous pyrites. 6. The *earthy ore of cobalt* is of a greeniſh white or of a yellow color, and of a ſoft and friable texture. This ſpecies ſeems to be an ochre of cobalt, and is formed perhaps from the flowers of cobalt further decompoſed, in the ſame manner as a martial ochre is formed from the ſaline eﬄoreſcence of decompoſing pyrites, when this eﬄoreſcence is further decompoſed by expoſure to moiſt air; by which the vitriolic acid contained in it is expelled, and the eﬄoreſcence is changed from a ſaline ſtate to that of an ochre or calx. Beſides theſe proper ores of cobalt, it is alſo found in a blue clay along with native ſilver, in ores of biſmuth, and in the mineral called kupfer-nickel. *See* NICKEL.

The ſil[illegible] although [illegible] valuable metal, is generally in ſo ſmall a quantity, [illegible] not be worth the trouble of obtaining on purpoſe from this mineral. The cobalt is therefore always operated upon for the ſake of the blue.

If well-calcined cobalt be treated with phlogiſton and fluxes, like other metallic calxes, it will be reduced to a ſemi-metal, called by Mr. Brandt, who firſt diſcovered it, the *Regulus of Cobalt*.

This regulus, and alſo the calx of cobalt, amongſt other ſingular properties, has that of making a very curious ſympathetic ink, by being diſſolved in aqua regia. *See, for what further relates to cobalt, the articles* SMALT, ZAFFRE, AZUR, REGULUS *of* COBALT, *and* INK (SYMPATHETIC).

CLXXVIII. COCHINEAL. (*r*)

CLXXIX. COERULEUM MONTANUM. (*s*)

CLXXX. COHESION. By coheſion is meant the adheſion which the integrant or the conſtituent parts of bodies have to each other.

CLXXXI. COHOBATION. Cohobation is an operation by which the ſame liquor is frequently diſtilled from the ſame body, either with an intention to diſſolve this body, or to produce ſome change upon it. This is one of thoſe operations which the ancient chemiſts practiſed with great patience and zeal, and which are now neglected.

To make this operation eaſier, and to prevent the trouble of frequently changing or moving the veſſels employed, a particular kind of alembic is contrived, very convenient and well adapted, called a *Pelican*. *See* PELICAN.

CLXXXII. COLCOTHAR. Colcothar is the ſubſtance which remains from the calcination and diſtillation of martial vitriol with a violent fire.

Vitriolic acid does not adhere ſo ſtrongly to the iron of the martial vitriol as to be capable of reſiſting the action of a ſtrong fire; therefore when this vitriol is heated intenſely and during a long time, it loſes more and more of its acid, which is diſſipated if the calcination be performed in open veſſels, and which may be diſtilled with proper apparatus. When the vitriol loſes its

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(*r*) COCHINEAL. From an ounce of cochineal Neuman obtained by diſtillation two ſcruples of phlegm, four ſcruples of urinous ſpirit, fifteen drops of oily ſpirit, twenty-two grains of volatile alkali, five ſcruples and two grains of empyreumatic oil, and two drams and two ſcruples of a reſiduum containing five grains of fixt lixivial ſalt. The ſame author found that of four drams of cochineal, three drams were ſoluble in water, and nearly as much in ſpirit of wine.

Cochineal infuſed or boiled with water produces a crimſon tincture inclining to purple. Fixed alkali renders the crimſon deeper, but leſſens its luſtre. Volatile alkali heightens the color without diminution of luſtre. The beſt method of applying volatile alkali for this purpoſe in dying was found by Mr. Hellot to be, by dipping the cloth dyed with cochineal in a ſolution of ſal-ammoniac, and then throwing into the ſolution ſome pot-aſh, by which the volatile alkali of the ſal-ammoniac is diſengaged. By a ſmall quantity of vitriolic acid the crimſon decoction of cochineal is rendered purple, by more of that acid it is rendered fleſh-colored, and by ſtill more colorleſs. This color is firſt changed to a yellow, and afterwards deſtroyed by nitrous acid. Solution of tin in aqua regia heightens the color of this decoction to a ſcarlet. French dyers give a ſcarlet tinge to this decoction by turmeric; but this tinge does not penetrate the cloth, and is not durable. *See* DYING.

(*s*) COERULEUM MONTANUM, *mountain-blue*, called by ſome authors *chryſocolla*, is a blue ore of copper. *See* ORES *of* COPPER.

acid, it acquires a red color, and becomes an earthy matter. The calx of iron, whether it has been deprived of phlogiſton by fire or by acids, is always of this red color: but the iron contained in vitriol ſuffers this alteration during the calcination. When the calcination is finiſhed, what remains of the vitriol has ſtill ſome taſte, and even the property of becoming moiſt when expoſed to air. Theſe qualities are cauſed by ſome remaining acid which adheres obſtinately to the earth of the iron, and which the fire could not expel. As this acid is very much concentrated, and is not combined with the calx of iron in the colcothar, as it was with the iron itſelf in the vitriol, becauſe the phlogiſton of the iron is loſt by calcination, we need not wonder that this calcined vitriol ſhould powerfully imbibe moiſture from the air, although vitriolic does not.

This remaining acid may be taken from the colcothar by waſhing with water. The colcothar then has no taſte, does not attract moiſture from the air, and is called *Sweet Earth of Vitriol.*

Unwaſhed colcothar is uſed in medicine, but only externally. It may be properly applied to all putrid, ſanious and fungous ulcers, becauſe it is antiſeptic, ſtrongly tonic, aſtringent, and even corroſive, from its remaining uncombined vitriolic acid. *See* VITRIOL (MARTIAL) *and* CALCINATION.

CLXXXIII. COLOPHONY. Colophony, or roſin, is the reſinous reſiduum after the diſtillation of the light oil from turpentine. It has alſo the properties of other reſins, and the ſame principles may be obtained from it by analyſis. *See* BALSAMS (NATIVE); TURPENTINE; *and* RESIN.

CLXXXIV. COLOCYNTH. (*t*)

CLXXXV. COLORS. (*u*)

CLXXXVI. COMBINATION. By the word *combination*, we ought to underſtand the union of two bodies of different natures, from which a new compound body reſults. For example, when an acid is united with an alkali, we ſay that a combination betwixt theſe two ſaline ſubſtances takes place, becauſe from this union a neutral ſalt reſults which is compoſed of an acid and an alkali. *See* COMPOSITION.

CLXXXVII. COMBUSTION. Combuſtion is nothing elſe than the diſengagement of the inflammable principle contained in ſeveral kinds of bodies, which are therefore called *combuſtible.*

The principle of inflammability is united in greater or leſs quantity with bodies, and in ſeveral different manners; hence the diverſity occaſioned in the phenomena of combuſtion.

If the phlogiſton of a body be in large quantity, and in an oily ſtate, this body is very combuſtible, and burns with a bright flame, accompanied with ſmoke and ſoot. Wood, dry vegetables, reſins, oils, fat, are combuſtible bodies of this kind.

If the phlogiſton of a body be not in an oily ſtate, but in large quantity, or not very intimately combined, this body may alſo be very combuſtible, and may

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(*t*) COLOCYNTH, or COLOQUINTIDA, is a bitter fruit, from an ounce of which Neuman extracted by ſpirit three ounces and a half, and by water ſeven ounces and a half.

(*u*) *Colors. See* BLACK, BLUE, &c. *and* DYING.

even burn with flame. But this flame is ſlighter and generally leſs luminous than the flame of oily bodies; beſides, it is accompanied with no ſmoke or ſoot. Spirit of wine, ſulphur, phoſphorus, charcoal, ſome metallic matters, and particularly zinc, are combuſtible bodies of this kind. The flames of phoſphorus and of zinc are nevertheleſs very luminous.

Laſtly, bodies containing phlogiſton which is not in an oily ſtate, and which is in ſmall quantity, or ſtrongly combined with other uncombuſtible principles, burn difficultly without any ſenſible flame; ſuch are certain animal coals, ſoot, aſhes of vegetables containing very little phlogiſton, and imperfect metals.

The grand principle concerning combuſtion in general is, that no combuſtible matter can burn without acceſs of air, and that the more immediate its contact with air is, the more rapid and compleat is its combuſtion. *See* Air.

For this reaſon, even the moſt inflammable bodies, as ſpirit of wine and ethereal oils, do not burn but at their ſurface, becauſe that only is expoſed to air. For the ſame reaſon, inflammable bodies, when reduced to vapor, burn rapidly and inſtantaneouſly, becauſe they are all expoſed to air at once. Laſtly, for the ſame reaſon, ſome bodies, though full of phlogiſton, ſuch as fat, oils, &c. cannot burn without a heat ſufficient to reduce them into vapor.

The practical methods of promoting, accelerating, and of compleating the combuſtion of the inflammable principle of bodies may alſo be naturally deduced from what we have ſaid on this ſubject. Theſe methods conſiſt in applying as much of theſe bodies as poſſible to the air. Thus by directing a current of air upon the burning bodies, their combuſtion is accelerated and augmented in proportion as this current is ſtronger, as the effects of bellows and air-furnaces evidently prove.

Moſt oily bodies, as wood, burn with much flame, which laſts while any ſenſible quantity of oil remains: after which the flame ceaſes. They are not however yet deprived of all their inflammable principle, a part of which remains in the ſtate of coal. Then the remaining part of the body may continue to burn, if it contains much phlogiſton, but without a luminous flame, and in the manner of charcoal.

In proportion as the phlogiſton is conſumed by this ſecond combuſtion, what remains of it becomes more and more difficultly combuſtible; not only becauſe the leaſt fixed and adherent part of it is firſt burnt, but alſo becauſe the proportion of incombuſtible matter, to which this phlogiſton is united, becomes greater and greater. Hence when this combuſtion has arrived at a certain point, that is, when a ſmall portion of phlogiſton only remains ſtrongly combined, and alſo covered and defended by a large quantity of incombuſtible matter, this remaining phlogiſton will not burn alone, and is nearly in the ſame ſtate as that of moſt metallic matters. If, therefore, this combuſtion is to be compleated, which then is called *calcination*, fire muſt be applied from ſome other fuel, with which the body to be calcined or dephlogiſticated is to be penetrated, and kept red-hot; and as much air is at the ſame time to be applied to the body, till no longer any marks appear of its inflammable principle. Aſhes of vegetables, ſoot, coals of oils and of animal matters, and ſeveral metallic ſubſtances, contain ſome phlogiſton in this laſt ſtate.

When the phlogiſton of theſe ſubſtances is to be entirely burnt or diſſipated, all the means capable of favoring combuſtion ought to be made to concur.

The ſubſtances ought to be firſt divided into very ſmall parts, becauſe then they preſent more ſurface to the air than when in one maſs. They are then to be expoſed to the action of fire in a convenient veſſel, ſo that the air may have free acceſs; as for example, in a wide-mouthed teſt, and under a muffle open on the ſide at which air is introduced into the furnace. To accelerate further this operation, a current of air may be directed upon the ſurface of theſe bodies, and they may be frequently ſtirred, that all their parts may be ſucceſſively preſented to air. The ſtrongeſt fire which the matter can ſuſtain without fuſion ought to be applied; becauſe a melted body forms always one maſs, and preſents leſs ſurface than when it is divided in ſmall detached parts. Thus fuſible bodies, as aſhes, alkaline ſalts and metals, ought to be calcined with a moderate heat, and proportioned to their fuſibility.

The laſt portions of the phlogiſton of certain bodies are ſo difficultly combuſtible, that notwithſtanding all theſe means united, they never can be entirely burnt.

Some of them even, as the perfect metals, are conſidered as bodies entirely incombuſtible, becauſe they can ſuſtain the moſt violent fire during entire months, without ſuffering any ſenſible alteration. Nevertheleſs, Junker affirms, that gold and ſilver may be calcined, if they are treated during ſix months, by reverberation, in the manner of Iſaacus Hollandus.

Although the certainty of this experiment has not been ſufficiently confirmed by repeated trials, the method of calcining theſe metals propoſed by this chemiſt agrees ſo well with the great principles of combuſtion, that its ſucceſs ſeems very probable. *See* CALCINATION.

CLXXXVIII. COMPOSITION *of* BODIES. Chemical compoſition is the union and combination of ſeveral ſubſtances of different natures, from which a compound body reſults. From this union of bodies of different nature a body is formed of a mixed nature, which Becker and Stahl have called a *mixture*, and which may be called a *combination* or *chemical compoſition*, to avoid the equivocal ſenſe of the word *mixture*, by which may be underſtood only a mere interpoſition of parts, and which therefore would give a very falſe idea of chemical compoſition, in which a mutual adheſion takes place between the combined ſubſtances.

When the ſubſtances conſidered by chemiſts as *ſimple*, or *primary principles*, are combined together, they form the firſt compounds, to which Becker and Stahl give, by way of excellence, the name *Mixts*. The ſame chemiſts call the bodies formed from the union of theſe mixts, *compounds*. When they treat of more complicated combinations, they talk of *decompounds* and *ſurdecompounds*.

This diſtribution of bodies, more or leſs compounded, is juſt and conformable to experience. But the names given by Becker and Stahl are not ſufficiently clear and accurate.

A more ſimple and clear method of diſtinguiſhing theſe ſeveral claſſes of bodies ſeems to be by numbers indicating their degree of compoſition. Thus we might ſay, compounds of the firſt, of the ſecond, of the third degree, &c. as Mr. Macquer propoſes in his courſe of chemiſtry.

CLXXXIX. CONCENTRATION. The concentration of a body conſiſts in approximating its proper and integrant parts, by taking away ſome ſubſtance interpoſed betwixt theſe parts, and which is extraneous or ſuperabundant to the body to be concentrated. Thus, for inſtance, a ſolution of any ſaline ſubſtance in water may be concentrated by expelling part of the water of this ſolution. But cuſtom has applied the word concentration to the dephlegmation of acids, and particularly of vitriolic acid by diſtillation, and of vinegar by congelation. We proceed to both theſe concentrations.

CXC. CONCENTRATION *of* VITRIOLIC ACID.

Vitriolic acid, procured either from vitriol or from ſulphur, is never ſufficiently pure for chemical operations. It always contains ſome extraneous ſubſtances from which it muſt be purified.

The heterogeneous matters which chiefly affect the purity of vitriolic acid, are ſuperabundant water by which it is weakened, and inflammable matter by which it is rendered black and ſulphureous. Theſe two ſubſtances are ſeparable by one and the ſame diſtillation, which is called the *concentration*, or the *rectification of vitriolic acid.* This acid ought to be diſtilled, whether it be both watery and ſulphureous, or have only one of theſe faults.

To explain what paſſes in this operation, and the management which muſt be obſerved, we will firſt conſider what happens in the concentration of vitriolic acid, which is only diluted with ſuperabundant water, and not phlogiſticated. We will then proceed to the changes produced upon this acid by diſtillation, when it is ſufficiently free from water, and is only phlogiſticated.

When vitriolic acid, diluted with ſuperabundant water, is to be concentrated, if it contains a conſiderable quantity of water, it may be diſengaged from the greateſt part of this ſuperfluous water in ſtone or glaſs bottles, without the apparatus of diſtillation. The greater the quantity of water which is united with the vitriolic acid, the leſs ſtrongly does a part of it adhere. As this water is much more volatile than vitriolic acid, it evaporates by almoſt the ſame degree of heat which is requiſite to the evaporation of pure water. While the water exhales, the parts of the vitriolic acid remaining in the veſſel are approximated, and the acid becomes more and more concentrated and ſtrong. Thus the operation proceeds very well to a certain point, and even better than by diſtillation. But when the acid has arrived at a certain degree of concentration, it cannot be compleated in open veſſels; becauſe the ſmaller which the quantity is of water united to the acid, the more ſtrongly it adheres; ſo that it cannot be ſeparated without a heat ſufficient to raiſe the acid alſo, which therefore in open veſſels would be loſt. But alſo another and more remarkable inconvenience occurs, which is, that when vitriolic acid begins to be much dephlegmated and very ſtrong, it becomes ſo greedy of moiſture that it attracts that of the ſurrounding air, as Mr. Beaumé has well obſerved, and perpetually combines with it; ſo that every inſtant it reſumes as much water from the air as it loſes by evaporation. The concentration of this acid muſt therefore be compleated in cloſe veſſels by diſtillation.

For this diſtillation, a retort of good glaſs, capable of reſiſting acids, muſt be filled half full with the vitriolic acid to be concentrated, and ſet in a ſand-bath covered entirely with ſand. After a receiver has been adapted to it, heat muſt be applied, and very gradually augmented till drops are diſtilled.

If the vitriolic acid contains little water, the diſtillation does not begin but with a conſiderable degree of heat, and the drops which fall into the receiver are very acid. Theſe drops fall very ſlowly, and the diſtillation muſt not be too much haſtened. As the concentration advances, the drops follow each other at longer intervals, although the acid contained in the retort acquires more and more heat. Towards the end of the operation, and when the acid is much concentrated, care muſt be taken not to encreaſe the heat ſo much as to make the acid boil, which cannot be effected with leſs than a red heat. By this heat all the acid may be raiſed at once, in drops and burning vapors, which paſs precipitately, and generally burſt the retort.

When this accident happens, whether it proceeds from haſtening the diſtillation too much, or from cold air ſtriking the retort, the concentrated and burning acid is almoſt entirely reduced to white, thick, ſuffocating vapors which inſtantly fill the laboratory. The operators ought to remove themſelves from ſuch hurtful vapors.

The duration of this operation, and the quantity of phlegmatic acid to be diſtilled, ſo that the vitriolic acid ſhall be left highly concentrated, are abſolutely indeterminate, as they depend on the degree of ſtrength which this acid had before its concentration. The vitriolic acid, which was formerly kept by druggiſts, required that one half of it ſhould be drawn off by diſtillation to make the remaining part twice as heavy as water. At preſent, it is much ſtronger, although cheaper. Some may be got very concentrated, and which only requires to be dephlogiſticated in the following manner.

The vitriolic acid manufactured in the great, and ſold in commerce, is always mixed with more or leſs inflammable matter, by which it is rendered black and opake. It may be entirely diſengaged from this extraneous matter by a diſtillation ſimilar to that above deſcribed.

The firſt portions of ſuch an acid which paſſes in diſtillation are a very penetrating, volatile, ſulphureous acid. If the phlogiſticated vitriolic acid which is rectified be alſo phlegmatic, the diſtillation may be ſo managed that the liquor ſhall ſlightly boil. This liquor continues black till it is concentrated to a certain degree; when by help of a ſtrong heat which it then acquires, the concentrated acid acts upon the inflammable matter, diſſipates it, or completely burns it. The liquor in the retort becomes gradually clearer, and at length perfectly white and tranſparent. If this acid has alſo the requiſite degree of concentration, the operation is finiſhed when it thus becomes perfectly white and tranſparent. The retort muſt be left in the ſand-bath till it is cold, and then the acid is to be poured into a clean, dry, cryſtal-glaſs bottle; conſidering that the ſmalleſt piece of inflammable matter is capable of phlogiſticating and blackening rectified vitriolic acid; and that any moiſture, beſides weakening the acid, might occaſion ſuch heat as to break the bottle. When the acid is poured into the bottle, the neck of this bottle ought to be wiped dry, and cloſed by a glaſs ſtopper, accurately fitted and well wiped. The mouth of the bottle ought alſo to be guarded from duſt by being covered with leather.

The phlegmatic or ſulphureous liquor, which paſſed over into the receiver, is called *Spirit of Vitriol*. It is clear and white, and may be uſed in many operations where concentrated vitriolic acid is not requiſite, or it may be concentrated and rectified.

CXCI. CONCENTRATION *of* VINEGAR *by* CONGELATION. Vinegar produced by the acetous fermentation is a vegetable acid much uſed in chemiſtry. As this acid is mixed with much extractive matter and ſuperabundant water, chemiſts have endeavored to render it more pure and ſtrong.

It may eaſily be diſengaged by a ſingle diſtillation from almoſt all its extractive matter; *ſee* VINEGAR (DISTILLED); but it cannot ſo eaſily be deprived of its ſuperabundant water. If vinegar be diſtilled with intention to concentrate it, as vitriolic acid is, the moſt watery and leaſt acid part would always riſe firſt; but the operation would ſucceed very imperfectly, becauſe this acid is almoſt as volatile as water. To procure the concentration of vinegar, other expedients muſt be uſed. Chemiſts have diſcovered ſeveral which ſucceed well. For inſtance, by combining this acid with fixed matters, ſuch as fixed alkalis and metals, and afterwards ſubjecting to diſtillation the ſalts reſulting from ſuch combinations, a very concentrated acid of vinegar is obtained, called, *Radical Vinegar. See upon this ſubject* TERRA FOLIATA TARTARI, SALT *of* LEAD, CRYSTALS *of* VERDIGREASE, and VINEGAR (RADICAL). We proceed here to deſcribe another method of concentrating vinegar, by which indeed it cannot be ſo much dephlegmated as by the preceding methods, but it is much more ſimple, and has ſome peculiar advantages. The method is effected by congelation, or freezing.

Stahl ſeems to be the firſt who employed this method. Since which time Mr. Geoffroy has made many experiments on this ſubject, a relation of which is to be found in the Memoirs of the Academy for the year 1739.

As acids reſiſt congelation much more than water, if vinegar be expoſed to a cold ſufficient to ſink the mercury of Mr. Reaumur's thermometer eight or ten degrees below the figure 0, a conſiderable quantity of ice will be formed. This ice, being ſeparated from the reſt of the unfrozen liquor, conſiſts of ſcarcely any thing but pure water, and the unfrozen liquor is a much ſtronger vinegar. By expoſing again this vinegar to another and ſtronger froſt, more ice is formed in it, leſs hard than the firſt ice, and ſomewhat reſembling ſnow, becauſe it contains a certain quantity of unfrozen acid; and may therefore be ſet aſide for the extraction of this acid. The acid remaining after the ſecond congelation is greatly ſtronger. This concentration of vinegar may be much encreaſed by repeating the congelation with greater cold Mr. Geoffroy relates in the quoted memoir, that vinegar which has been already concentrated by froſts of preceding years, and eight pints of which had been reduced to two pints and a half by the froſt of January 29, 1739, was at length ſo much concentrated, that two drams of this vinegar, the ſaturation of which before theſe concentrations would have required ſix grains of ſalt of tartar, did now require forty-four grains for that purpoſe.

Stahl aſſures us, that wine may be well concentrated by the ſame method. He ſays, that he expoſed to froſt different kinds of wine, and that he had procured by this means two thirds, or three quarters, of pure phlegm.

Wines thus concentrated had a thick conſiſtence, were very ſtrong, and were preſerved without change many years, in places, where the free acceſs of air alternately hot and cold, according to the ſeaſons, would have ſoured or ſpoiled any other wine in a few weeks. The general opinion that wines are ſpoiled and entirely weakened by froſt proceeds undoubtedly from the ice not being taken off, but left to mix again with the wine when it thaws. Perhaps alſo ſome delicate wines are conſiderably altered by froſt.

Wallerius ſays, that in the northern countries cold is ſucceſsfully uſed to concentrate ſea-water, and to approximate the particles of ſalt, by ſeparating the ice as ſoon as it is formed, and which is little elſe but pure water.

We might be induced to believe that the mineral acids might be concentrated by congelation, as indeed they might be, if they were mixed with a very great quantity of water: but their adheſion to water is ſo ſtrong, that they cannot be much concentrated by this method.

CXCII. CONDENSATION. By the condenſation of a body we ought to underſtand the approximation of its integrant parts, ſo that it occupies a ſmaller ſpace, and that its ſpecific gravity is augmented, without the loſs of any heterogeneous matter. For inſtance, air, forced by compreſſion to confine itſelf within a narrower ſpace, is to be conſidered as condenſed.

CXCIII. CONE. (x)

CXCIV. CONTRAYERVA. (y)

CXCV. COPAL. (z)

CXCVI. COPPER. Copper, called alſo by chemiſts *Venus*, is an imperfect metal of a red ſhining color. It is harder, more elaſtic and ſonorous, but a little leſs ductile than ſilver. It is nevertheleſs conſiderably ductile, and may be drawn into wire as fine as hair, or beaten into leaves almoſt as thin as thoſe of ſilver.

The tenacity of the parts of this metal is very conſiderable, ſince a copper wire, the diameter of which is a tenth part of an inch, is capable of ſupporting a weight of 299¼ pounds without breaking.

(x) CONE (MELTING). This is a hollow cone formed of copper or of braſs, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to reſt. Its uſe is to receive a maſs of one or more metals melted together and poured into it. This maſs when cold may be eaſily ſhook out of the cone, from the figure of the veſſel. Alſo if a melted maſs, conſiſting of two or more metals, or other ſubſtances not combined together, be poured into this veſſel, its figure facilitates the ſeparation of theſe ſubſtances according to their reſpective denſities. The cone ought to be well heated before the melted maſs is poured into it, that no moiſture may be contained, by which a dangerous exploſion might be occaſioned. It ought alſo to be greaſed internally with tallow, to prevent the adheſion of the fluid matter.

(y) CONTRAYERVA. The leaves of this plant are ſaid to afford a poiſon employed by Indians for poiſoning arrows, to which poiſon the root of the ſaid plant is ſaid to be an antidote. From an ounce of the root Neuman extracted, with water, three drams and half a ſcruple; and from the ſame quantity, with ſpirit of wine, five ſcruples and two grains.

(z) COPAL, improperly called *gum opal*, is a hard, ſhining, tranſparent, citron-colored, odoriferous, concrete juice of an American tree, but which has neither the ſolubility in water common to gums, nor the ſolubility in ſpirit of wine common to reſins, at leaſt in any conſiderable degree. By theſe properties it reſembles amber. By digeſtion in linſeed oil, with a heat very little leſs than ſufficient to boil or decompoſe the oil, it may be diſſolved. This ſolution, diluted with ſpirit of turpentine, forms a beautiful tranſparent varniſh, which, when properly applied, and ſlowly dried, is very hard and very durable. This varniſh is applied to ſnuff-boxes, tea-boards, and other utenſils. It preſerves and gives luſtre to paintings, and greatly reſtores the decayed colors of old pictures by filling up the cracks, and rendering the ſurfaces capable of reflecting light more uniformly.

Copper weighed by the hydroſtatical balance loſes in water about an eighth or a ninth part of its weight (*a*). It has a very ſingular and diſagreeable ſmell and taſte. It cannot be fuſed without a violent degree of heat ſufficient to make it white.

Copper, being an imperfect metal, may be burnt, deſtroyed, and calcined by the united action of fire and air: for which reaſon its quantity is always diminiſhed by melting it without covering its ſurface.

When it is expoſed to a great fire with free acceſs of air, it ſmokes, loſes part of its weight, and communicates to flame beautiful green and blue colors.

It reſiſts more than any other imperfect metal the action of fire before it ſuffers any conſiderable alteration. When a clean and poliſhed copper plate is gently and gradually heated, its ſurface is covered with all the colors of the rainbow. This appearance proceeds from the developement, and the different ſtates of the phlogiſton of the metal. (*b*)

When this metal is expoſed to red heat with contact of air, its ſurface becomes quickly tarniſhed, and its metallic luſtre is changed into a dark and earthy appearance; and if this heat be continued during a certain time, the ſurface of the metal is burnt and deſtroyed; ſo that when it cools, it is found to have no longer any adheſion with the uncalcined copper, but to be ſeparated in ſcales from the difference of the contraction, occaſioned by cooling, upon the uncalcined copper, and upon its burnt ſurface.

When this ſurface is ſeparated, the copper beneath it ſeems clean and ſhining; but it will ſoon ſuffer the ſame change as the former, if it be again heated; and thus a piece of copper may be entirely reduced to ſcales no longer poſſeſſed of brilliancy, ductility, or other metallic properties, and which are called *burnt copper*.

This calcined copper is leſs fuſible than copper in its metallic ſtate: when expoſed to a great fire, but a very ſmall quantity of copper is obtained from it; the reſt of it is changed into a dark and opake vitrified ſcoria; except the ſcales have been mixed with ſome matter capable of reſtoring to them phlogiſton; in which latter caſe a quantity of malleable copper is obtained nearly equal to that of the ſcales employed. *See* Reduction *of* Metals.

Theſe copper ſcales, which are at firſt but imperfectly calcined, may be entirely deprived of phlogiſton and of their metallic properties by a ſecond calcination under a muffle continued ſufficiently long.

(*a*) The ſpecific gravity of European copper is to that of water as 8843, and of Japaneſe copper as 9000 to 1000.

(*b*) All metals are ſubject to receive theſe colors or iriſes by heat; and from the color of any part of a piece of metal we may diſcover what degree of heat has been applied to that part, as the ſame degree of heat always gives the ſame color to the ſame metal: hence artiſts, by obſerving the colors acquired by ſteel expoſed to fire, are enabled to apply to pieces of that metal the preciſe degree of heat which they have found by experience to produce the required hardneſs, in the operation of tempering ſteel. Thus they know, that the heat which gives a blue color to ſteel is ſufficient to give the requiſite hardneſs for ſprings. The iriſes, or different colors given to different parts of one piece of metal, are occaſioned by the heat being unequally applied. Theſe colors are produced by a more or leſs perfect calcination of the ſurface of the metal expoſed to heat.

Copper is alſo affected by the combined action of air and water: hence its ſurface is apt to tarniſh, and even to be covered with a green ruſt, called *verdegriſe*.

This ruſt is copper partly decompoſed, and deprived of part of its inflammable principle; for it cannot be melted into copper without much loſs, excepting its phlogiſton be reſtored by ſome reductive flux. Theſe are alterations to which all the imperfect metals are ſubject. *See* METALS (IMPERFECT).

This metal is eaſily ſoluble by all acids, and its ſolutions are green or blue. *(c)*

Vitriolic acid, although the ſtrongeſt of all, diſſolves copper more difficultly than any other: it muſt be concentrated and aſſiſted by conſiderable heat and time to diſſolve this metal. From this ſolution reſults a neutral ſalt, which forms beautiful blue cryſtals, called *blue vitriol*, or *vitriol of copper*. *See theſe words.*

Nitrous acid diſſolves copper very quickly with violence and efferveſcence; and during the ſolution it takes from the metal part of its phlogiſton. The nitre formed by this ſolution is a very deliqueſcent ſalt. The ſalts formed by marine acid or by aqua regia with copper are alſo very deliqueſcent.

Vegetable acids, and particularly thoſe of wine and of vinegar, may be eaſily united with copper. The former acid forms with it the verdegriſe uſed in painting (*See* VERDEGRISE); and the ſecond, when ſaturated, forms the ſalt called *cryſtals of verdegriſe*, or *cryſtal of Venus*. *See* CRYSTALS *of* VERDEGRISE.

All acids united with copper may be ſeparated from it without any intermediate ſubſtance, and merely by fire.

Calcareous earths, fixed and volatile alkalis, ſeparate copper from any acid, and precipitate it in form of a beautiful green powder. The color of theſe precipitates of copper is cauſed by a portion of the ſalts which remain united with them. As the metal thus diſſolved and precipitated has loſt part of its phlogiſton, particularly when it has been diſſolved by vitriolic and nitrous acids, theſe precipitates of copper cannot be melted into malleable copper without addition of phlogiſton: but if they be melted with glaſſes, or vitreſcible matters, and the fire be properly managed, they communicate their colors to theſe ſubſtances: hence they may be applied to imitate precious ſtones of a green color, or nearly green, as the emerald, and beryl or aqua marina, and for ſeveral ſhades of painting upon pottery and porcelain.

Some metallic matters, which have a ſtronger affinity than copper has to acids, are therefore capable of precipitating this metal from its ſeveral ſolutions. Iron particularly has this property; for which reaſon, if it be added to a ſaturated ſolution of copper in an acid, it will be attacked and diſſolved by this acid, and it will precipitate the copper; and thus the ſolution of copper is changed into a ſolution of iron. While this happens, a remarkable phenomenon appears: the copper thus precipitated is in its metallic ſtate and brilliancy. This effect, which ſeems to be general whenever a metallic matter is ſeparated from an acid by means of another metallic matter, can only happen becauſe the

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(c) Solutions of copper in vitriolic acid, vegetable acid, oil, or water, are green; that in marine acid is at firſt brown or yellow, and becomes afterwards green; and that in aqua fortis is of a bluiſh-green color: volatile or fixed alkalis make the ſolutions of copper in acids blue: a ſolution of copper in volatile alkali, expoſed to air, is blue.

precipitating metal ſeparates entirely and exactly all the acid from the precipitated metal, which earths and alkalis ſeem incapable of doing; and becauſe the precipitating metal ſupplies enough of phlogiſton to the acid, to prevent the acid from retaining the phlogiſton of the precipitated metal, which earths and alkalis are alſo incapable of doing.

However that be, this precipitation of copper in its metallic ſtate, by the intervention of iron, is capable of impoſing upon, and actually has impoſed upon perſons ignorant of chemiſtry; who, perceiving that a piece of iron, dipt into a liquor in which they ſuſpected no copper, became covered over with copper, imagined that this liquor had the property of changing iron into copper.

This property which iron has of ſeparating copper from acids has been applied to uſe. In England, the water in a copper mine is impregnated with a great quantity of blue vitriol, and from which much copper is extracted by means of iron immerſed in it. In Germany ſome copper ores are ſo pyritous, that they cannot be advantageouſly treated by ordinary fuſions, but are reduced into vitriol, and by means of the iron which is put into the lixivium of this vitriol, called *cement water*, a conſiderable quantity of copper is obtained, which would otherwiſe be loſt. *See* ORES, PYRITES, *and* VITRIOLS.

Copper produces, with reſpect to mercury and ſilver diſſolved in acids, the ſame effects which itſelf ſuffers from iron; that is, it ſeparates theſe metals ſo exactly from the acids with which they are united, that they appear with their metallic luſtre.

This property of copper is employed to obtain ſilver diſſolved by ſpirit of nitre in the operation of parting. This ſilver is generally very pure.

If a very clean plate of copper be immerſed in a ſolution of mercury, particularly if this ſolution have an exceſs of acid, it will be very ſoon covered over with mercury, which adheres to it, and which, when wiped and waſhed, makes a very white and brilliant ſilvering. This alſo is one of the experiments which exhibit an appearance of tranſmutation capable of aſtoniſhing thoſe who are ignorant of chemiſtry. Every day credulous perſons are deceived by tricks no better than this.

No metal is more ſoluble than copper. It is acted upon by almoſt all ſaline and metallic ſubſtances, and probably for this reaſon ancient chemiſts have called it *Venus*, conſidering it as proſtituted to all ſubſtances.

Fixed and volatile alkalis eaſily diſſolve copper, either directly, or ſtill better if it has been previouſly diſſolved in acids. *See* ALKALIS (FIXED *and* VOLATILE).

Moſt neutral ſalts corrode its ſurface, and reduce it into verdegriſe. The ſame effect is produced by all oils and fat matters, from the latent acid which they contain.

Sulphur has conſiderable action upon copper, and even has a greater affinity with it than with any other metal excepting iron: hence it may be ſeparated from almoſt all metals by means of ſulphur, which alſo renders it much more fuſible. Copper is formed into a mineral or pyritous ſtate by union with ſulphur; and if this compound be expoſed to fire, ſo that the ſulphur ſhall be burnt, its acid will act upon the copper, and reduce it to blue vitriol.

Copper may be eaſily united with all metals and ſemimetals, and with them forms allays; of which ſee the detail at the articles Allay, Bronze, Tombac, *and* Similor.

As this metal is combuſtible, it may be ſeparated from the perfect metals by calcination, which is accelerated by means of lead, as in refining; or by nitre, which generally much accelerates the calcination of all combuſtible bodies; ſo that by repeated projections of nitre upon melted gold and ſilver allayed with copper, the nitre burns the phlogiſton of the copper, and reduces this metal into a ſcoria which floats upon its ſurface: but the nitre muſt be added gradually, and but a little at a time, particularly if much copper be in the allay, becauſe the detonation which it occaſions is ſufficient to diſſipate ſome of the perfect metals. *See* Nitre.

The affinities of copper, according to Mr. Geoffroy, are mercury and lapis calaminaris, or rather zinc; and according to Mr. Gellert, gold and ſilver. (*d*)

CXCVII. COPPER (WHITE). White copper is an allay of copper, zinc, and arſenic, in certain proportions, and is white as ſilver. The preciſe proportions cannot be eaſily determined, and the allay cannot without difficulty be made, becauſe of the volatility of the two ſemimetals. Nevertheleſs, a very beautiful and ſilver-like white copper is made by ſome artiſts, who carefully conceal their method of preparation.

As this allay is not much uſed, from its very noxious quality, chemiſts have not conſidered it; otherwiſe any of them who knew the management of metals might probably diſcover it.

The medicinal virtues of copper are treated of under the article Brass.

CXCVIII. CORAL (*e*)

CXCIX. CORK. (*f*)

CC. CORK (FOSSIL). (*g*)

CCI. CREAM. This name is applicable to all ſubſtances which ſeparate from a liquor, and collect upon its ſurface; but it is particularly given to the following ſubſtances:

(*d*) Wallerius ſays, that if a mixture of calx of copper and ſal ammoniac be expoſed during a certain time to air, from that maſs, by diſtillation with ſoap, mercury may be obtained; whence he infers, that either mercury is a component principle of copper, or that at leaſt *ſome* part of the copper is convertible into it.

(*e*) Coral *and* Coralline are ſhells of marine animals of the polypus kind, and poſſeſs the ſame chemical properties as the freſh ſhells of oyſters and other ſhell-fiſh, that is, they are calcareous earths impregnated with ſome animal principles. *See* Earths (Calcareous). From ſixteen ounces of coral, Neuman obtained by diſtillation ſix ſcruples of a volatile, alkaline, oily ſpirit, two or three grains of empyreumatic oil, and a reſiduum containing five ſcruples and a half of fixed ſalt, probably ſea-ſalt. The quantities of theſe component parts were found to vary according to the freſhneſs of the coral analiſed.

(*f*) Cork is the bark of a tree of the oak kind, which grows in the ſouthern parts of Europe. From an ounce of cork Neuman extracted, by boiling in water, two ſcruples; and from the ſame quantity he obtained, by digeſtion in ſpirit of wine, two ſcruples and two grains.

(*g*) Cork (Fossil), *Suber montanum.* This name is given to a ſtone which is a ſpecies of amianthus, conſiſting of flexible fibres looſely interwoven, and ſomewhat reſembling vegetable cork. This is the lighteſt of all ſtones. By fire it is fuſible, and forms a black glaſs. It poſſeſſes the general properties of amianthus. *See* Amianthus.

CCII. CREAM *of* LIME. The cream of lime is that moſt attenuated part of quicklime, and moſt approaching to a ſaline ſtate, which is diſſolved by water with which quicklime is ſlaked, or even in which ſlaked lime is boiled. This matter ſeparates from lime-water by cryſtallization during the evaporation of the water; and as water only evaporates at its ſurface, this earthy cryſtallization is alſo formed there. It forms a ſemi-tranſparent pellicle, which becomes thicker and thicker till it ſeparates into pieces, and falls to the bottom by its weight in form of ſcales. The cream of lime has the ſame properties as ſlaked lime has. *See* QUICKLIME. (*h*)

CCIII. CREAM *of* MILK. This is the moſt oily part of milk; which being naturally only mixed, and not diſſolved in milk, and being ſpecifically lighter than the other parts, ſeparates from them by reſt, and collects on the ſurface of the milk, from which it is generally ſkimmed to compleat the diſengagement of the oily from the caſeous and ſerous parts, that is, to make it into *butter*. *See* BUTTER *and* MILK.

Cream of milk, which is generally called ſimply *cream*, is not only an agreeable aliment when recent, but is alſo uſeful in medicine as a lenient, when applied to tetters and eriſipelas accompanied with pain, and proceeding from an acrid humor.

CCIV. CREAM *of* TARTAR. Cream of tartar is, properly ſpeaking, that part of the concrete acid of tartar which cryſtallizes firſt, and like a pellicle on the ſurface of water in which tartar has been boiled, with intention to purify it, and to ſeparate from it its moſt ſaline part. Thus this ſubſtance called *cream*, from its manner of formation, does not eſſentially differ from the cryſtals of tartar which are formed in the liquor; and theſe cryſtals are accordingly, as well as the ſaline pellicle, generally called cream of tartar, theſe two matters being confounded together by one name, from which no inconvenience reſults. *See* TARTAR.

CCV. CRIMSON. (*i*)

CCVI. CROCUS. This Latin word, ſignifying *ſaffron*, has been applied as a name to earths of certain metals, which in color ſomewhat reſemble ſaffron: ſuch particularly are the earths of iron and of copper, each of which is therefore called *crocus*, the firſt being the *crocus of mars* or *of iron*, and the ſecond *the crocus of copper*: but the word *ſaffron* is more commonly employed, and particularly applied to the earth of iron. *See* SAFFRON.

CCVII. CRUCIBLE. (*k*)

(*h*) Cream of lime is very different from flaked quicklime. The latter ſubſtance is calcareous earth deprived of fixable air, and combined with water: it is cauſtic, ſoluble in water, and poſſeſſes all the properties of quicklime, from which it differs only in containing a quantity of water. Cream of lime is calcareous earth, which having been deprived of fixable air by calcination, and diſſolved by water, is, by expoſure to air, again combined with fixable air; by which it is rendered mild, cryſtallizable, unſoluble in water, and reſtored to its original ſtate before calcination. *See* AIR (FIXABLE).

(*i*) CRIMSON. A crimſon color may be given to ſilks and woolen cloths by cochineal. *See* COCHINEAL. A leſs durable crimſon may be given by Brazil wood. For the color called by dyers demi-crimſon, the root of madder is mixed with cochineal. *See* RED *and* DYING.

(*k*) *See* POTTERY.

CCVIII. CRYSTAL. Cryſtal, called alſo *rock-cryſtal*, or *natural cryſtal*, is a hard, tranſparent ſtone, of the figure of a priſm with ſix faces, which is terminated at each of its extremities by hexagonal pyramids.

The moſt beautiful rock-cryſtal is that which is perfectly clear, white, and tranſparent. It is frequently cut; and luſtres, vaſes, and toys are made of it, as of other beautiful ſtones. Rock-cryſtals, like the precious ſtones, are of all colors; and they receive their color, as the precious ſtones do, from metallic and phlogiſtic ſubſtances. Some of them are brown, and almoſt black; theſe may be rendered white and tranſparent, by making them red-hot, which muſt be done very gently and gradually, to prevent their cracking, which they are very apt to do as well as other vitrifiable ſtones. *See* EARTH (VITRIFIABLE. (*l*).

(*l*) *Cryſtal, rock cryſtal,* or *quartz-cryſtal*, is a tranſparent ſtone of the claſs of earths called by ſome ſiliceous, and by others vitrifiable. Its form is that of an hexagonal priſm, one or both ends of which are terminated by hexagonal pyramids. Some of them conſiſt of theſe two pyramids joined together at their baſes, without any priſm interpoſed. Cryſtal is frequently found adhering to quartz; and, according to Cronſtedt, it is nothing but quartz, which he affirms always aſſumes this hexagonal form, when its accretion or cryſtallization has not been interrupted. Cryſtals are either colorleſs, or colored. Colored cryſtals are called by ſome authors *fluors*. Thoſe which are red are called *falſe rubies*; the violet-colored, *falſe amethyſts*, or, according to Cronſtedt, the *true amethyſts*; the yellowiſh-red, *falſe hyacinths*; the blue, *falſe ſaphirs*; yellow, *falſe topazes*; the greeniſh-yellow, *falſe chryſolites*; the green, *falſe emeralds*; the ſea-green, *falſe beryls*. Some cryſtals are duſky, brown, or blackiſh, but ſtill tranſparent. Cryſtals poſſeſs the general properties of the earths called vitrifiable. *See* EARTHS (VITRIFIABLE). Colorleſs cryſtals reſiſt the moſt violent and long continued fire. *See Mr.* D'ARCET's *Memoir upon Vitrification*, Academy of Sciences, 1766. Moſt of the colored cryſtals are fuſible by violent fire. They probably receive this fuſibility, as well as their color, from metallic ſubſtances. Colorleſs cryſtals may be tinged with various colors, ſo as to imitate precious ſtones. For this purpoſe, Neri, in his *Art of making Glaſs*, directs that pieces of clear cryſtal ſhould be laid upon a mixture of four parts of orpiment, four parts of crude antimony, and one part of ſal ammoniac, placed in a crucible, to which another crucible inverted is well luted: the crucibles are to be placed in a furnace, and ſurrounded with charcoal: after a red heat has been gradually applied, and the fire extinguiſhed, the upper pieces of cryſtal will have acquired a fine golden color, reſembling opals, and variegated with beautiful ſpots: the lower pieces of cryſtal will have acquired a fine color, reſembling that of the ſkins of vipers. He gives another proceſs, in which he directs the cementing mixture to be compoſed of two parts of yellow orpiment, two parts of white arſenic, one part of crude antimony, and one part of ſal ammoniac. He directs alſo, that no bellows or ſtrong current of air ſhould be applied to the fire, by which he ſays, that the cryſtals are apt to be cracked, probably by making the heat too intenſe, and that the crucibles ſhould not be opened till they have been gradually cooled. Cryſtals thus treated reſemble rubies, opals, agates, turquois, marbles, chryſolites. Mr. Pott ſays, that he found the color of ſome cryſtals much improved by repeating the operation. Baptiſta Porta directs, that cryſtals ſhould be colored by keeping them immerſed during four or five hours in a melted mixture of ſulphur, crude antimony, orpiment, arſenic, and tutty. In theſe operations, the cryſtals ſeem to imbibe ſome of the vapors of the metallic ſubſtances. The chief difficulties ſeem to be to prevent the cracks to which the cryſtals are very ſubject by this treatment, and to procure a ſufficient penetration. Probably both theſe purpoſes might be effected by a very ſtrict attention to the gradual application, and to the maintenance of a due degree of heat.

CCIX. **CRYSTAL (FACTITIOUS).** The word cryſtal has been applied to glaſſes produced by art, which from their tranſparency and whiteneſs imitate rock-cryſtal. In fact, ſome are made as beautiful as the fineſt rock-cryſtals, but not nearly ſo hard. The heat of ordinary vitrification ſeems incapable of producing glaſs as hard as rock cryſtal; nor do our crucibles ſeem capable of ſuſtaining the requiſite heat, if it could be raiſed. *See the method of making cryſtals at the words* GLASS *and* VITRIFICATION.

CCX. **CRYSTAL (MINERAL).** Mineral cryſtal, called alſo *Salt of Prunella*, is melted nitre detonated with a little ſulphur, and caſt into form of tablets.

Nitre is one of the neutral ſalts which contains the leaſt water in its cryſtallization, or which loſes the leaſt water by a true fuſion, and is alſo one of the moſt fuſible ſalts.

To make mineral cryſtal, very pure nitre muſt be put into a clean crucible, and quickly fuſed, taking care that no aſhes or coal fall in. When the nitre is fuſed, it is to be detonated with ſulphur, in the proportion of a dram of the latter to a pound of the former. It is then to be poured into a copper, or rather a ſilver baſon, in which it is to be agitated while yet fluid, that it may fix in form of cakes or tablets.

No other effect is produced upon the nitre by the ſmall quantity of ſulphur with which it is detonated, than to introduce into it a proportionable quantity of vitriolated tartar, called *Sal Polychreſt of Glaſſer*. In all other reſpects, chemical and medicinal, mineral cryſtal is nitre, and may be given like this, from four grains to ten or twelve, in a quart of proper drink. It is cooling, ſedative, aperitive and diuretic. This preparation then ſeems uſeleſs, ſince the ſame intentions may be better accompliſhed by well purified nitre. *See* NITRE.

CCXI. **CRYSTALLIZATION.** This word is ſometimes employed to ſignify ſubſtances which are cryſtallized, or whoſe parts are ſo arranged that they form regular figures. In this ſenſe, we ſay *ſtony cryſtallizations*, *pyritous cryſtallization*, &c.

CCXII. **CRYSTALLIZATION** *of* **SALTS** *and of other Subſtances.* If the word cryſtallization were to be confined to its moſt proper ſenſe, as it ſeems to have been formerly, it could only be applied to operations by which certain ſubſtances are diſpoſed to paſs from a fluid to a ſolid ſtate by the union of their parts, which ſo arrange themſelves that they form tranſparent and regularly figured maſſes, like native cryſtal; from which reſemblance the word cryſtallization has evidently been taken.

But modern chemiſts and naturaliſts have much extended this expreſſion, and it now ſignifies a regular arrangement of the parts of any body which is capable of it, whether the maſſes ſo arranged be tranſparent or not. Thus opake ſtones, pyrites, and minerals, when regularly formed, are ſaid to be cryſtallized, as well as tranſparent ſtones and ſalts.

The opacity and tranſparency of ſubſtances are juſtly diſregarded in conſidering whether they be cryſtallized or not; for theſe qualities are perfectly indifferent to the regular arrangement of the integrant parts of ſubſtances, which is the eſſential object of cryſtallization.

This being eſtabliſhed, cryſtallization ought to be defined an operation by which the integrant parts of a body, ſeparated from each other by the interpoſition of a fluid, are diſpoſed to unite again and to form ſolid, regular, and uniform maſſes.

To underſtand as much as we can of the mechaniſm of cryſtallization, we muſt remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obſtacle.

2. That in ſimple, or little-compounded bodies, this tendency of integrant parts is more obvious and ſenſible than in other more compounded: hence the former are much more diſpoſed to cryſtallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that the primitive integrant molecules of every different body have a conſtantly uniform and peculiar figure.

4. That theſe integrant parts cannot have an equal tendency to unite indiſcriminately by any of their ſides, but by ſome preferably to others, excepting all the ſides of an integrant part of a body be equal and ſimilar; and probably the ſides, by which they tend to unite, are thoſe by which they can touch moſt extenſively and immediately. The moſt general phenomena of cryſtallization may be conceived in the following manner.

Let a body be ſuppoſed to have its integrant parts ſeparated from each other by ſome fluid. If a part of this fluid be taken away, theſe integrant parts will approach together; and as the quantity of intervening fluid diminiſhes, they will at laſt touch and unite. They may alſo unite, when they come ſo near to each other that their mutual tendency ſhall be capable to overcome the diſtance betwixt them. If, beſides, they have time and liberty to unite with each other by the ſides moſt diſpoſed to this union, they will form maſſes of a figure conſtantly uniform and ſimilar. For the ſame reaſon; when the interpoſed fluid is haſtily taken away, ſo that the integrant parts ſhall be approximated, and be brought into contact before they have taken the poſition of their natural tendency, then they will join confuſedly by ſuch ſides as chance preſents to them; they will in ſuch circumſtances form ſolid maſſes, whoſe figures will not be determinate, but irregular and various.

In every cryſtallization all that we have deſcribed may be obſerved.

If cryſtallization be taken in the general ſenſe we have given to it, ice is a true cryſtallization. Water, for inſtance, is to be conſidered as a body whoſe integrant parts are ſeparated from each other by the interpoſition of the matter of fire. Melted metals are alſo to be conſidered in the ſame manner. The fluidity of theſe bodies is to be attributed to this matter of fire, with which theſe bodies are penetrated. When therefore theſe liquefied bodies cool, which can only be by taking away this igneous matter which penetrates them; if the approximation of the integrant parts, which is a neceſſary conſequence of this cooling, be made ſo ſlowly that they ſhall have time and liberty to unite by the ſides moſt diſpoſed to this union, they will always form maſſes of a conſtant and ſimilar figure.

Thus when water freezes ſlowly, and is not agitated by any motion which can diſturb the order in which the integrant parts tend to unite, it forms regular cryſtals of ice, and always of the ſame form.

Theſe cryſtals which may be called cryſtals of water, are long, needle like maſſes, flattened on one ſide, joined together in ſuch a manner that the ſmaller are inſerted into the ſides of the greater; and thus theſe compound cryſtals have the appearance of feathers, or of leaves of trees.

The moſt remarkable circumſtance attending this cryſtallization is, that the angle formed by the inſertion of the ſmaller needles into the ſides of the larger ones is always of the ſame width, that is, ſixty degrees. However, it is ſometimes double, that is, 120 degrees; but it is conſtantly one of theſe two angles, and it is to be remembered that theſe angles are complements to each other, that is, they are together equal to two right angles. We are obliged to Mr. Mairan for theſe fine obſervations, which he has given at full length in an excellent diſſertation on ice.

Metals, ſulphur, and ſeveral other bodies not much compounded, which fix and become ſolid after fuſion, aſſume always a regular arrangement whenever they are ſlowly enough cooled for that purpoſe. The ſtar of the regulus of antimony has been long obſerved with wonder. Alchemiſts, who ſaw wonders in all their operations, conſidered this ſtar as ſomething myſterious and ſignificant; but the wonder ceaſed when the cauſe of it was inveſtigated by ſo good a philoſopher as Mr. Reaumur, and diſcovered to be the tendency which the integrant parts of the regulus of antimony have to arrange themſelves in an uniform manner; for this arrangement always happens, when the regulus of antimony has been well fuſed, and ſlowly cooled. Mr. Macquer and Mr. Beaumé having fuſed ſilver with great heat, and afterwards very ſlowly cooled it, obſerved that this metal alſo arranged itſelf in a regular manner. Mr. Beaumé obſerved the ſame effect upon applying to all the other metals and ſemi-metals the ſame treatment. Every metallic ſubſtance was found to have its peculiar form, which Mr. Beaumé propoſes to determine.

What we have ſaid concerning bodies, which being fuſed by fire, are cryſtallized when they become ſolid by cold, may alſo be applied to all thoſe whoſe integrant parts ſwim ſeparately from each other in a fluid ſuch as water. Thus all kinds of earths, and of metallic and mineral matters, which are found in that ſtate, may be cryſtallized by taking away ſome of the watery fluid which ſeparates their integrant parts. A ſlow evaporation of the water which contains theſe ſubſtances allows their parts to approximate and to unite together by the moſt ſuitable ſides, and to form maſſes of a determinate and conſtant figure.

In this manner are formed the cryſtallizations of precious ſtones, of rock cryſtal, of ſpars, of certain ſtalactites, and of all ſtony bodies found ſo frequently well cryſtallized. The regular forms of moſt pyrites, of many ores and metallic minerals, and even of ſome pure metals, ſuch as gold, ſilver, copper, which are found regularly arranged and ramified, ought to be attributed to the ſame mechaniſm, that is, to the ſlow ſeparation of their integrant parts from the water in which they are ſuſpended.

But of all the ſubſtances thus ſuſceptible of cryſtallizing by their ſeparation from water, ſalts are moſt diſpoſed to it, and afford the beſt examples of cryſtallization; becauſe all ſaline ſubſtances being eſſentially ſoluble in water, are liquefied by this fluid in a much greater quantity than the bodies we have mentioned, which, properly ſpeaking, are only miſcible with water.

This property which ſalts have of being ſoluble by water muſt depend on a certain affinity or adheſion of their integrant parts to thoſe of water; and from this adheſion we can deduce the phenomena peculiar to the cryſtallization of ſalts, and the differences obſervable betwixt the cryſtallization of theſe, and that of other ſubſtances to which water has not the ſame affinity. We ſhall relate what is moſt neceſſary to be known concerning the cryſtallization of ſalts, an object of great importance in chemiſtry.

The cryſtallization of a ſalt diſſolved in water may be procured, as evidently appears from what we have ſaid, by taking away the diſſolving water: and as moſt ſalts are leſs volatile than water, and may even be conſidered comparatively as fixed ſubſtances, this ſubſtraction may be commodiouſly made by the evaporation of a ſufficient quantity of water. The parts of the ſalt, being ſufficiently approximated by this evaporation, will unite together and form cryſtals, as we have already explained concerning other ſubſtances. But as the ſaline parts adhere to thoſe of the water, this circumſtance occaſions an eſſential difference in the cryſtallization; which is, that the ſalt when cryſtallizing, does not ſeparate itſelf from all the water with which it was united in ſolution, but retains ſome part of it with ſome force; and this portion of water adhering to, and even combined with the parts of ſalt, makes with it one whole or entire body; whence ſaline cryſtals are compounded of cryſtallized ſalt, and of water which makes part of theſe cryſtals. This water is called by chemiſts the *water of cryſtallization.*

As this water of cryſtallization is ſuperabundant to the eſſence of the cryſtallized ſalt, it may be taken from it by evaporation with a certain degree of heat, without any change produced upon the eſſential properties of the ſalt; ſo that it may be again diſſolved and cryſtallized as at firſt. But we muſt obſerve, that the water of cryſtallization cannot be taken from any ſalt without deſtroying the form, or at leaſt the conſiſtence and tranſparency of the cryſtals; and when the ſalt is to be re-diſſolved and re-cryſtallized, it retains in this ſecond cryſtallization the ſame quantity of water preciſely as it had in the firſt.

Hence we ought to conclude that this water of cryſtallization is not eſſential to a ſalt, as a ſalt, but that it is eſſential to a ſalt as being cryſtallized; ſince to it the ſaline cryſtals owe their form, tranſparency, and even the coheſion of their parts.

The quantity of water of cryſtallization varies much in different ſalts. Some of theſe, as alum, Glauber's ſalt, and martial vitriol, contain about half their weight of water; and others, as nitre and ſea ſalt, contain but a ſmall quantity. Selenites contains an almoſt inſenſible quantity of water. This difference ſeems to depend on the ſtate of the acid in theſe ſalts; and in general the more firmly an acid is combined with its baſis, the leſs water it retains in cryſtallization.

A very important remark to be made upon this water of cryſtallization, is, that when the cryſtallization is properly managed, this water is perfectly pure, and contains no ſubſtance foreign to the cryſtallized ſalt. To Mr. Beaumé we owe this diſcovery. By many experiments he was convinced that no neutral ſalt, with a baſis of fixed alkali, retains in its cryſtals either ſuperabundant acid or alkali, or any other matter foreign to the neutral ſalt, although even this ſalt had been cryſtallized in a liquor that was acid, alkaline, or impregnated with any other ſubſtance foreign to the ſalt; and that if ſometimes theſe heterogeneous ſubſtances are found included in ſaline cryſtals, they have no adheſion to them, ſince they may be ſeparated merely by draining upon brown paper, without any change produced upon the cryſtals of the ſalt; whereas the water of cryſtallization cannot be taken away without a deſtruction of the cryſtals. The cauſe of this phenomenon will eaſily appear when we recollect that ſalts retain the water of their cryſtallization by the adheſion of theſe ſalts to water; and that if a ſalt be diſſolved in water impregnated with acid, alkali, or other ſubſtance foreign or ſuperabundant to the ſalt diſſolved, this ſalt does not adhere either to the ſuperabundant acid, or alkali, nor to the other extraneous ſubſtances, but to the water alone.

Evaporation of water, in which a ſalt is diſſolved, is not the only method by which the ſalt can be cryſtallized. Another method which may be uſed with ſucceſs, at leaſt for the cryſtallization of moſt ſalts, is by application of cold to the water ſuſpending the ſalt. The reaſon of this is as follows.

All ſalts are ſoluble in water, but not with equal facility, ſome of them requiring much water, and others very little: moſt of them are more eaſily diſſolved, and in greater quantity, by hot than by cold water; and others with nearly equal facility, and in equal quantity by both hot and cold water. This being eſtabliſhed, when boiling water, that is, water heated as much as poſſible, ſuſpends in ſolution all that it can diſſolve of thoſe ſalts which are more ſoluble by hot than by cold water, if this water be cooled, the portion of ſalt which was diſſolved merely by the heat of the water, will be collected and cryſtallized as faſt as the water cools. We may alſo obſerve, that when this cooling of the water is very quick, the cryſtals it occaſions are ſmall, irregular, and ill-ſhaped; and that the more ſlowly the cooling is produced, the larger and better formed the cryſtals are.

What has been hitherto ſaid concerning the regular forms taken by certain liquefied matters during their fixing or becoming ſolid, is entirely applicable to this kind of cryſtallization of ſalts. This cryſtallization is not effected by a ſubſtraction of water but of fire, by which ſubſtraction a condenſation of the ſaline liquor is produced, and conſequently a ſufficient approximation of the parts of the diſſolved ſalt to diſpoſe them to unite, and to form cryſtals; and as in this caſe, the fluidity or the ſolidity of the ſalt is ſolely occaſioned by the preſence or abſence of the matter of fire, theſe ſalts diſſolved by heat, and cryſtallized by cold, may be compared to melted metals, the parts of which are regularly arranged by a ſlow cooling. But with regard to ſalts we muſt obſerve, that as their cryſtallization is performed in a fluid to which they have an adheſion, they retain the ſame quantity of water of cryſtallization, whether the operation was performed by cold or by evaporation.

Hence we may perceive, that evaporation and cooling are the two principal methods of cryſtallizing ſalts. Sometimes it is proper to employ one only of theſe methods, and at other times both together, according to the particular nature of the ſalt to be treated. If it be one of thoſe ſalts which are better cryſtallized by cooling than by evaporation, ſuch as nitre, for inſtance, then the former method ought to be uſed; for nitre cannot be well cryſtallized by evaporation alone, becauſe the water which keeps it diſſolved would be reduced almoſt to nothing before the cryſtallization would begin, and the liquor would be ſo concentrated that the parts of the ſalt would not arrange themſelves properly.

When, therefore, nitre is to be cryſtallized, the water is to be evaporated ſo far only that when it cools cryſtals ſhall be formed. This degree of evaporation is known by taking a few drops of the hot liquor, and cooling them quickly; if the evaporation has been ſufficient, ſmall cryſtals may be perceived inſtantly formed. As the evaporation here mentioned does not occaſion the cryſtallization of the nitre, but is only preparatory to it, this evaporation may be either quick or ſlow without inconvenience. The liquor may be made to boil as faſt as poſſible, and the cryſtals of nitre will be no leſs perfect, provided that this liquor when ſufficiently evaporated be ſlowly cooled: when it is perfectly cooled, no more cryſtals will be formed in it. It ought then to be poured off, and again evaporated, when by a ſecond cooling it will furniſh more cryſtals, and this treatment is to be continued to the end.

But if well formed cryſtals are to be obtained of one of thoſe ſalts which are nearly as ſoluble in cold as in boiling water, and which conſequently cannot be cryſtallized by cold, evaporation is the only method to be uſed. Common ſalt is a proper inſtance of this kind.

Water impregnated with common ſalt muſt be evaporated to obtain cryſtals; and when the liquor contains much more water than is neceſſary to the ſolution of the ſalt, the evaporation may be carried on as faſt as poſſible till the cryſtallization is ready to begin. This point is known by a thin, ſaline pellicle, which floats on the ſurface of the liquor, and ſeems as if duſt had fallen upon it. This pellicle is compoſed of the firſt portions of ſalt beginning to cryſtallize. It is always formed at the ſurface; becauſe this ſalt cryſtallizes by evaporation only, and evaporation is only at the ſurface.

Mr. Rouelle, in his Memoir concerning the Cryſtallization of Sea-ſalt, ſays, that he has obſerved, that when the evaporation has been very ſlow, and with a heat not much exceeding that of ſummer, the cryſtals of common ſalt are formed at the bottom and not at the ſurface of the liquor. As this appears quite contrary to the manner in which this ſalt cryſtallizes in all other circumſtances, have we not reaſon to believe, that in this inſenſible evaporation the cryſtals of ſea-ſalt are formed firſt at the ſurface, as in all other evaporations, but that they cannot be perceived from the extreme ſmallneſs of their ſize at firſt; and becauſe the heat is too weak to dry their upper ſurface, and to make them adhere to the air, theſe ſmall cryſtals fall to the bottom without being perceived, and there become larger by the union of other ſmall cryſtals, formed and precipitated in the ſame manner?

If the evaporation when brought to the point of cryſtallization was to be ſtopt, and the liquor to be cooled after it has been filtrated, and put into a bottle to prevent further evaporation from the remaining heat, ſcarcely any cryſtals would be formed in it, but the ſalt would remain diſſolved in the water. If, on the contrary, the evaporation ſhould be haſtily continued, ſalt would indeed be formed in great quantity; but as its parts would not have time to arrange themſelves properly, the cryſtals would be ſmall and ill-formed *. The evaporation therefore ought to be continued, but ſlowly: and by this method very beautiful cryſtals will be obtained, partly in cubes, partly in hollow pyramids formed by cubes †.

The rules of cryſtallization moſt ſuited to the nature of each ſalt muſt be obſerved, not merely to obtain well-formed cryſtals; for if their figure was once determined, the regularity of their cryſtallization would be afterwards of no conſequence: but the cryſtallization of ſalts relates to an affair of much more importance, which is their purity.

We have already ſaid, that, when a ſalt is well cryſtallized, the water of its cryſtallization is very pure, and contains none of the heterogeneous matters which happened to be mixed with the ſolution of the ſalt before cryſtallization. This obſervation may be extended to other ſalts which may happen to be diſſolved in the ſame liquor. If then ſeveral ſalts be diſſolved together, we may almoſt always ſeparate them exactly from each other, by cryſtallizing each of them according to their character; for amongſt the almoſt infinite number of ſalts now known, ſcarcely two ſhow preciſely ſimilar phenomena in cryſtallization. We may, from the example of ſeparating nitre and common ſalt when diſſolved together in the ſame liquor by cryſtallization, ſhow how ſuch ſeparation may be done in general, even when ſeveral ſalts happen to be ſo confounded. This is certainly one of the fineſt and moſt uſeful problems in chemiſtry.

Let us then ſuppoſe that nitre and ſea-ſalt, diſſolved in the ſame liquor, are to be ſeparated from each other. The method of effecting this will appear evidently from conſidering what we have ſaid concerning cryſtallization; and this method will be found to conſiſt in employing alternately evaporation and cooling. Firſt of all then, the liquor muſt be evaporated. If, during the evaporation, a pellicle appears on the ſurface, and no cryſtals of nitre appear in a ſmall quantity of the liquor when haſtily cooled, then we diſcover that common ſalt is in greater quantity than the nitre. In this caſe the evaporation muſt be continued, and the common ſalt ſeparated as faſt as it is formed, till a ſmall quantity of the liquor, when haſtily cooled, ſhews ſmall needle-like cryſtals of

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* Although cryſtals of ſea-ſalt are generally leſs regular when formed by a haſty than by a ſlow evaporation, this irregularity is, however, leſs ſenſible in this ſalt than in moſt others, and its cryſtals always tend to a cubic form, or at leaſt appear compoſed of cubes. From this obſervation we have reaſon to believe that the primitive integrant molecules of this ſalt are cubes: hence we may conceive that as all the ſides of this ſalt are equal and ſimilar, from their union regular ſolids ought to reſult, more or leſs approaching to the cubic figure, by whatever ſide they may have been united. *Note of the Author.*

† Although in a moderate evaporation a very large quantity of cryſtals of common ſalt is formed in quadrangular, hollow, and inverted pyramids, the cubic figure is nevertheleſs the primitive and eſſential form of this ſalt; for theſe pyramids are all compoſed evidently of cubes. Beſides, they are only formed accidentally, by the union of ſeveral quadrangular priſms compoſed of cubes, which are ſucceſſively applied to the ſides of a firſt cube; which being formed at the ſurface of the liquor, remains ſuſpended there, by the adheſion of its upper dried ſurface to the air. As this cube is beſides a little ſunk into the liquor by its weight, ſo that the liquor riſes along its ſides, it becomes by that means a very proper foundation for the formation of this pyramid. This mechaniſm is explained at length in Junker's book, and in a Memoir of Mr. Rouelle concerning the cryſtallization of ſea-ſalt, printed in 1745. *Note of the Author.*

nitre; then the liquor is to be left to cool, that the nitre may have an opportunity of cryſtallizing by cooling; after which the evaporation is to be reſumed that more common ſalt may be ſeparated, and to diſſipate ſo much water that cryſtals of nitre ſhall again be formed by cooling. Thus theſe ſalts may be alternately cryſtallized, one by cooling and the other by cryſtallization, till they are entirely ſeparated.

If, in the beginning of the operation, the liquor had, upon trial in ſmall quantity, given cryſtals of nitre by cooling, before any pellicle had appeared upon its ſurface, the common ſalt would then have been known to be in much leſs quantity than the nitre. In this caſe, the nitre would have been cryſtallized firſt, but always by cooling. The quantity of nitre, which exceeds that of common ſalt, having been thus ſeparated, the common ſalt would then begin to cryſtallize in its turn by evaporation.

Several eſſential remarks are to be made upon this ſeparation of ſeveral ſalts from each other by cryſtallization.

Firſt, although the two ſalts, the method of ſeparating which we have given as an example, are the moſt capable of ſuch a ſeparation, becauſe ſea-ſalt is one of the ſalts which are leaſt of all to be cryſtallized by cooling; and on the contrary, nitre is one of thoſe which are beſt cryſtallized by this method; nevertheleſs, after a firſt cryſtallization of theſe two ſalts, ſuch as we have deſcribed, they are not entirely and perfectly ſeparated from each other: the ſea-ſalt contains ſome nitre, and the nitre contains ſome portion of ſea-ſalt; becauſe in cryſtallization one ſalt always takes with it a ſmall portion of another: but when two ſalts are ſo different from each other in this reſpect as theſe two, a perfect ſeparation may be eaſily made by diſſolving each of them ſeparately in more water, and by proceeding to their cryſtallization by the ſame method. As a new ſeparation is made by each cryſtallization, they may be obtained at laſt perfectly pure by repeating ſufficiently this management.

The ſecond remark to be made on the ſeparation of ſalts by cryſtallization is, that this ſeparation is ſo much more difficult and long, in proportion as the ſalts to be ſeparated are more ſimilar to each other in their manners of cryſtallization. For inſtance, if two ſalts, which are only capable of cryſtallizing by evaporation, as ſea-ſalt and vitriolated tartar, or by cooling, as nitre and Glauber's ſalt, they cannot be ever obtained quite pure and ſeparated from each other by any management: nevertheleſs, even in this caſe they may be in great meaſure ſeparated; firſt, becauſe the preciſe degree of evaporation, or of cold, which is neceſſary for the cryſtallizing of one ſalt, is generally ſomewhat different from that which is requiſite for the cryſtallization of another ſalt; ſecondly, becauſe although they ſhould reſemble each other much in this reſpect, ſome differences, which muſt be obſervable in the ſize and form of their cryſtals when well formed, will furniſh means of making at leaſt an imperfect ſeparation, which may be made more perfect by repeating this management.

But the ſeparation of ſome ſalts is attended with ſingular and even inſuperable difficulties. Such are the ſalts which have ſome action upon each other, and the parts of which have ſome adheſive power together. This action of neutral ſalts upon each other has been very little obſerved: it is, nevertheleſs, very ſenſible in ſome of them; ſuch are ſal ammoniac and corroſive ſublimate, which not only act as intermediate ſubſtances to each other, by which they can be diſſolved in greater quantities in water and in ſpirit of wine than they can ſingly, but which being diſſolved together in the ſame menſtruum, cannot be again cryſtallized ſeparately by any method; as Mr. Macquer has ſhewn in his Memoir concerning Mr. Garay's Tincture of Mercury, printed in the Collection of the Academy for the year 1755.

Some ſalts have ſo great affinity with water, and are ſo ſoluble by this menſtruum, that they can ſcarcely be cryſtallized. The ſolution of theſe ſalts requires to be evaporated almoſt to dryneſs, or to a thick conſiſtence, and then by cooling they generally form needle-like cryſtals applied longitudinally or tranſverſely to each other. When they are expoſed to the air, they attract humidity, and reſolve into a liquid ſtate. Mr. Rouelle was the firſt who deſcribed, in his Memoir concerning Salts in the year 1744, the cryſtallization of deliqueſcent ſalts, ſuch as marine ſalt and nitre with baſes of calcareous earth, of copper, and of iron, terra foliata tartari, and the ſalts formed by the union of the acids of vinegar and of tartar with iron and with copper.

All theſe ſo difficultly cryſtallizable ſalts may be eaſily ſeparated from ſalts which may be readily cryſtallized, with which they happen to be mixed; becauſe the former ſalts in the evaporations and coolings are always the laſt to cryſtallize.

Two of theſe ſalts, namely nitre and marine ſalt, with baſes of calcareous earth, are found mixed with nitre and marine ſalt with baſes of fixed alkali; both of them in the lixiviums of the manufacturers of nitre, and the latter in almoſt all the waters in which common ſalt is found to be naturally diſſolved: hence, when the proper operations are made to obtain nitre and ſea-ſalt, after all the evaporations and cryſtallizations, a very heavy ſaline liquor remains from which no cryſtals can be procured, called the *mother water*. Theſe mother-waters of nitre and of common ſalt are, then, nothing but theſe ſalts with earthy baſes almoſt pure; and if a cryſtallization of them were required, the method deſcribed by Mr. Rouelle in the quoted Memoir ought to be practiſed. But this is not a matter worthy the attention of the manufacturers, to whom the perfect purification of nitre and of ſea-ſalt, from an adhering portion of the ſalts with earthy baſis, is of much more importance, as we ſhall ſee when we ſhall treat of theſe ſalts.

Chemiſts have given much attention to this ſubject, the cryſtallization of ſalts; and particularly Mr. Rouelle has made many intereſting reſearches concerning it, which may be ſeen in his Memoir of 1744. But nevertheleſs, much remains yet to be done. The true form of all cryſtallizable ſalts, and the beſt methods of cryſtallizing them, are not yet determined; which will not appear ſurpriſing to thoſe who underſtand this ſubject, and who know that one and the ſame ſalt, although conſtantly tending to the ſame form, is nevertheleſs capable of diſguiſing itſelf in many ways, and of taking many different forms, according to the circumſtances during cryſtallization. The quickneſs or ſlowneſs of evaporation, the quantity of water evaporated, the more or leſs haſty cooling, and the different degrees of cold applied, the ſtate of the air and of the liquor with reſpect to reſt or motion, even the form and matter of the veſſel in which a ſalt is cryſtallized, are ſo many cauſes, which, acting ſucceſſively or together in many different ways, are capable of producing numberleſs varieties in the cryſtallization.

Of all the cauſes which we have mentioned, capable of varying cryſtallizations, the nature of the veſſel employed ſeems to deſerve leaſt our attention; yet this may produce ſome change from the greater or leſs adheſion which the ſalt may have to the ſeveral matters of which theſe veſſels are made. For inſtance, we can only attribute to the adheſion of ſalts to the ſides of the veſſels employed the property which moſt of them have to branch out in various manners; and to creep along the ſides of theſe veſſels, particularly when the cryſtallization is very ſlowly performed, ſo conſiderably that they frequently go even on the outſide of the veſſels. Mr. Beaumé has prevented this phenomenon by hindering the adheſion of the ſalts to the ſides of the veſſels, by rubbing theſe ſides with ſome oil.

From what has been ſaid concerning the action of neutral ſalts upon each other we may conceive, that when ſuch ſalts happen to be mixed together, they muſt produce conſiderable differences in cryſtallizing.

Many other important obſervations might be made on the cryſtallization of certain ſalts, but they will be better placed under the articles of the ſeveral ſalts which they concern. We are obliged alſo to leave to the underſtanding and reflection of our readers to draw from what we have ſaid many corollaries, the detail of which would be too long. We ſhall only mention a manner of cryſtallizing ſalts which is different from the methods by evaporation and by cooling, but which conſiſts alſo in taking away from the ſalt a portion of water which keeps it diſſolved. This method of cryſtallization is well effected by adding to a ſolution of a ſalt a ſufficient quantity of a ſubſtance which has no action upon that ſalt, but which has greater affinity than it with the water which keeps it diſſolved. Spirit of wine, for inſtance, has theſe properties with regard to many ſalts. Thus by adding a ſufficient quantity of rectified ſpirit of wine to a ſtrong ſolution of Glauber's ſalt, of vitriolated tartar, or of ſea-ſalt, this ſpirit of wine ſeizing the water neceſſary for the ſolution of the ſalts, obliges them to cryſtallize immediately: but as this cryſtallization is very haſtily made, and almoſt inſtantaneouſly, the cryſtals are always very ſmall and ill-formed. In this reſpect they reſemble the cryſtals of ſalts produced from a liquor which contained too little water to keep them diſſolved. This happens, for inſtance, when a ſtrong ſolution of alkaline ſalt is combined with concentrated vitriolic acid, to form vitriolated tartar; for this ſalt, which requires much water to keep it diſſolved, does not find enough in the liquor, and appears immediately in form of very ſmall cryſtals like ſand. The ſame thing may be ſaid of vitriols of ſilver and of mercury, of luna cornea, and of other metallic ſalts of this kind produced by adding vitriolic or marine acids to the white metals diſſolved in nitrous acid. Theſe ſalts appear immediately as precipitates, whenever they do not find water enough in the liquors to diſſolve them; and Mr. Rouelle juſtly obſerves, in his Memoir, that they are not precipitates, but true ſalts, which not finding water ſufficient for their ſolution, are obliged to be immediately cryſtallized, but in cryſtals ſo ſmall, from the rapidity of their cryſtallization, that they cannot be known to be cryſtals but with the help of a microſcope.

Notwithſtanding what has been ſaid concerning the irregularity of the cryſtals procured by adding a ſubſtance, which ſeizes the water of the ſolution of ſalts, yet if this addition was managed and gradually made, perhaps it might produce very beautiful and very regular cryſtals. Mr. Beaumé has actually obſerved, that when ſalts were cryſtallized in acid or alkaline liquors according to their nature, their cryſtals were infinitely larger and more regular than they would have been without this circumſtance. *Vegetable ſalt*, for inſtance, and *ſalt of Saignette*, require to be cryſtallized in an alkaline liquor; and *ſedative ſalt* requires an acid liquor, when it is obtained from borax by the intervention of an acid, if we deſire to have fine cryſtals of theſe ſalts. The cauſe of this muſt be, that acids or alkalis, having in general more affinity with water than neutral ſalts have, diminiſh the adheſion of theſe neutral ſalts with the water of the ſolution; for a too great adheſion of a ſalt to water may evidently be a great impediment to its cryſtallization. *See the words* SALT, SALTS (NEUTRAL), *and the ſeveral ſorts of neutral ſalts under their reſpective names.*

CCXIII. CRYSTALS. All neutral ſalts with metallic baſes ſuſceptible of cryſtallization are commonly called by chemiſts *Cryſtals*, when they are actually cryſtallized; and the name of the metal contained in the ſalt is added to diſtinguiſh it. Thus we ſay, *cryſtals of gold*, *of ſilver*, *of copper*, *of lead*, &c. But as theſe names do not indicate the acid contained in each ſalt, they ought to be diſuſed. Here we ſhall only mention two of theſe ſalts called cryſtals; becauſe they are almoſt always diſtinguiſhed by that name. Theſe are the *cryſtals of ſilver*, and *cryſtals of verdegriſe* or *of copper*.

CCXIV. CRYSTALS *of* SILVER, or LUNAR CRYSTALS. Cryſtals of ſilver are neutral ſalts with metallic baſes compoſed of nitrous acid ſaturated with ſilver. When very pure ſilver is diſſolved by very pure nitrous acid, if the acid be ſtrong, cryſtals will be perceived merely by the cooling of the ſolution. Theſe cryſtals are white, flattened like thin ſcales, and not very hard. When the nitrous acid uſed to diſſolve the ſilver is weak, no cryſtals are formed; becauſe the water in the acid is ſufficient to keep the newly formed ſalt diſſolved; but lunar cryſtals may eaſily be obtained from this dilute ſolution by evaporating the ſuperabundant water, and letting the liquor cool.

Very beautiful and white lunar cryſtals may alſo be obtained, although the ſilver employed be allayed with copper or iron: becauſe the ſalts formed by theſe two metals with nitrous acid are deliqueſcent, and are not ſo eaſily cryſtallizable as the ſalt with baſis of ſilver. In this caſe the ſolution ought to be evaporated, if it be neceſſary; and the cryſtals of ſilver will be cryſtallized by cooling, while the copper or iron will remain diſſolved. When the colored liquor is poured off, cryſtals willl be found ſufficiently white and almoſt pure; but to purify them perfectly, they ought to be drained, diſſolved again in very pure water, and again cryſtallized: then after they are well drained from the liquor, they will be found perfect and beautiful. This even is a method of ſeparating ſilver from the alloy of copper, or of iron; and of obtaining from ſtandard ſilver, or ſilver allayed with copper, as fine and colorleſs a ſolution as if teſted ſilver had been employed

Lunar cryſtals then are a true *lunar nitre*, or *nitre with baſis of ſilver*; and they accordingly have the property of deflagrating upon burning coals, almoſt as well as nitre, with baſis of fixed alkali. When this experiment is made, ſilver is found after the detonation incruſted upon the ſurface of the coal in its metallic ſtate.

Notwithſtanding this property which lunar nitre has of detonating with coals, a property which ſhews a ſtrong adheſion of nitrous acid with ſilver; yet this adheſion is not ſufficiently ſtrong to reſiſt a certain degree of heat; ſo that by calcination or diſtillation theſe two ſubſtances may be disjoined.

Lunar cryſtals may be melted with a very gentle, and leſs than a red heat. They eaſily loſe the water of their cryſtallization, and then congeal into a black maſs, which is generally caſt into moulds, and is called *Lapis infernalis*, or *lunar cauſtic*. *See* CAUSTIC (LUNAR).

This ſalt is very cauſtic, as the effects of the lunar cauſtic ſhew in ſurgery, although it has loſt a part of its acid in the fuſion which it receives. This corroſive quality of lunar cryſtals ſeems to render it unfit for internal uſe as a medicine; yet ſome phyſicians preſcribe it as a powerful evacuant of water. Boyle, though not a phyſician, but aſſiſted by ſome perſons of the faculty, propoſes a method of rendering theſe cryſtals of ſilver milder, and boaſts much of them as a remedy. His method conſiſts in adding to a ſolution of them in water another ſolution of an equal quantity of nitre, and evaporating the whole to dryneſs and whiteneſs, with a very gentle fire, by which a portion of the ſpirit of nitre is intended to be taken away without fuſing the ſaline maſs; after which, this ſaline powder is to be made into pills, by forming it into a paſte with ſome bread and water.

Little ſkill in chemiſtry is requiſite to ſhew, that nitre thus mixed with lunar cryſtals, being incapable of acting upon it, cannot render it milder, but muſt leave it unchanged.

Secondly, by the manner of drying this mixture of lunar cryſtals and nitre, leſs of the cauſticity of theſe cryſtals is deſtroyed than by forming them into lunar cauſtic, in which operation they ſuſtain a heat ſufficient to fuſe and to blacken them, and conſequently loſe more of their acid. After theſe conſiderations, we cannot believe that this remedy of Mr. Boyle is ſo mild and innocent as it has been repreſented. This is certain, that, notwithſtanding the praiſes given it by this philoſopher, its uſe has not yet been eſtabliſhed in medicine.

Lunar cryſtals are called by Lemeri *vitriol of ſilver*; but as they contain no vitriolic acid, this name does not ſuit them, and ought only to be given to the ſalt formed by the union of vitriolic acid with ſilver. *See* SILVER.

CCXV. CRYSTALS *of* COPPER, or *of* VENUS. By theſe names is meant a ſalt formed by the union of the acid of vinegar with copper.

This combination may be made by diſſolving directly copper in good diſtilled vinegar; but it is made much more commodiouſly, and more expeditiouſly, when the copper employed has been previouſly formed into verdegriſe; becauſe the copper in the verdegriſe is already divided and penetrated by a certain quantity of acid of wine: verdegriſe therefore is always uſed for the preparation of cryſtals of copper.

This operation is very ſimple. It conſiſts in diſſolving verdegriſe in good diſtilled vinegar till this acid be ſaturated. For this purpoſe a matraſs is to be uſed, and to be ſet in a ſand-bath with a gentle heat. When the vinegar diſſolves the verdegriſe, it takes a fine greeniſh-blue color. Some chemiſts call it alſo Tincture of Venus. When it ceaſes to act on the verdegriſe, it is to be decanted, evaporated, and cryſtallized. The beautiful greeniſh-blue cryſtals formed are cryſtals of copper. When this ſalt is expoſed to a dry air, it loſes eaſily the water of its cryſtallization, and its ſurface is reduced to a lighter-colored ſea-green powder.

The acid of vinegar does not ſtrongly adhere to the copper in this combination. It may be entirely ſeparated from it by diſtillation; and as it had loſt moſt of its ſuperabundant water when it united with the copper, it may by this method be obtained in its greateſt concentration. It is called *radical vinegar*, and improperly *ſpirit of Venus*. See *theſe words*.

The principal intention of chemiſts in making cryſtals of Venus is to obtain radical vinegar. But this preparation is alſo uſed by painters; for which reaſon large quantities of it are manufactured, and it is generally ſold under the name of *diſtilled verdegriſe*; probably becauſe diſtilled vinegar is employed in its compoſition. *See* COPPER *and* VINEGAR.

CCXVI. CUCURBIT. A cucurbit is a chemical veſſel employed in diſtillation, when covered with its capital or head. Its name comes from its lengthened ſhape, by which it reſembles a gourd: ſome cucurbits, however, are ſhallow and wide-mouthed. Cucurbits are made of copper, tin, glaſs, and ſtone-ware, according to the nature of the ſubſtances to be diſtilled. A cucurbit provided with its capital conſtitutes the veſſel for diſtillation called *Alembic*. See *this word*, *and* PLATES.

CCXVII. CUPEL. A cupel is a wide-mouthed earthen veſſel, like a flat cup, from which reſemblance it has been named.

The uſe of cupels is to contain gold and ſilver mixed with lead in the operations of refining and of eſſay, and to abſorb the litharge and other ſcorified matters formed in theſe operations.

For this reaſon cupels ought to be made of dry, porous earths capable of reſiſting the action of ſtrong fire, and of fluxes.

The aſhes of wood and of bones are the moſt proper earths for cupels. Theſe aſhes ought to be perfectly burnt and calcined; that is, till they become white, ſo that they contain no more inflammable principle, which might revivify the ſcorified metals, and occaſion an ebullition during the operation. They ought alſo to be well lixiviated, and deprived of all ſaline matter to avoid their fuſion.

To form cupels, aſhes thus prepared ought to be mixed with water into a paſte, to which a proper form is given by means of a mould. Sometimes they are made into a paſte with ſome beer; a ſmall quantity of clay is added, that they may be moulded more conveniently. *Roaſting teſts* made of clay are alſo called by ſome artiſts *cupels*; becauſe they have the ſame form as the refining and eſſay cupels. *See* ESSAY, *and* PLATES.

CCXVIII. CUPELLATION. Cupellation is an operation by which gold and ſilver are refined or eſſayed by ſcorification with lead upon the cupel. *See* REFINING *and* ESSAY.

D.

CCXIX. DAMPS. Theſe are noxious and even fatal exhalations or vapors, which infeſt ſubterranean places, and particularly mines, if the air be not frequently renewed.

The inſtances of fatal accidents cauſed by theſe vapors are too frequent. Moſt of them kill animals ſo ſuddenly that no aſſiſtance can be given.

Although all theſe vapors produce ſimilar effects, and occaſion ſudden and mortal faintings and ſyncopes, yet ſome differences may be obſerved in the properties and modes of acting of theſe vapors in different places. From which we may preſume, that they are not all exactly of the ſame nature.

Some of them are viſible, and appear in form of a fog: ſuch is that which is found in a quarry near to the mineral waters of Pyrmont; and of which Dr. Seip has given a deſcription in the Philoſophical Tranſactions. This vapor has a ſulphureous ſmell, deſtroys inſects, birds, and in general all animals which approach it, with ſymptoms ſimilar to thoſe which animals ſuffer when placed under an exhauſted receiver of an air-pump.

Others, though perfectly inviſible, produce the ſame effects. Such are, ſays the learned tranſlator of Lehman, thoſe which iſſue from a cave in Hungary, ſituated near Ribard, at the foot of Crapack mountains. Theſe vapors are ſo fatal that they kill birds, while in their flight they approach too near to the mouth of the cave.

Amongſt the noxious mineral exhalations we may alſo place thoſe which are found in the mines of Sal-gem in Poland. Theſe frequently appear in form of light flocks, threads, and webs, like thoſe of ſpiders. They are remarkable for their property of ſuddenly catching fire at the lamps of the miners with a terrible noiſe and exploſion. They inſtantly kill thoſe whom they touch. This exploſion is a true ſubterranean thunder. Similar vapors are found in ſome mines of foſſil-coal.

As arſenic is the greateſt poiſon of all mineral ſubſtances, as it is volatile, and abounds in almoſt all mines, many authors have ſuppoſed that damps contained ſomething arſenical. But this opinion is ſo far from being proved, that ſtrong reaſons induce us to believe that they are of a different nature. We are certain, and I know it from my own experience, that a perſon may be a conſiderable time expoſed to a large quantity of vapors of arſenic without ſuffering any of the ſymptoms occaſioned by damps, and even without being much incommoded.

Secondly, the effects produced by arſenic taken internally, even in a large quantity, although terrible, and always fatal, are not nearly ſo ſudden as thoſe occaſioned by damps, which inſtantaneouſly kill. Thirdly, no obſervation or experience have aſcertained the arſenical nature of any damps; and it is even demonſtrable, that many of theſe noxious mineral vapors are nothing elſe than volatile ſulphureous acid.

Laſtly, all thoſe which are not evidently volatile ſulphureous acid appear to be pure, or almoſt pure phlogiſton diſengaged from bodies without burning. They occaſion exactly the ſame accidents as exhalations of liver of ſulphur, of burning coals, and of matters undergoing the putrid or ſpirituous fermentations. The great inflammability of theſe vapors, when they are confined, and condenſed to a certain degree, ſuch as thoſe of coal-mines, is a demonſtrative proof of this opinion.

By art we may perfectly imitate theſe vapors. We know that when acids diſſolve imperfect metals, they take from them a conſiderable part of their inflammable principle. This principle is almoſt totally diſſipated in vapors during theſe ſolutions; and if the operation be made in a cloſe veſſel, when this is uncorked, and a lighted candle brought near its mouth, the vapor contained inſtantly catches fire, and occaſions an exploſion ſo much more violent as the quantity of vapor was greater. This phenomenon may be chiefly obſerved in the ſolution of iron in vitriolic acid diluted with a certain quantity of water. If after this exploſion the bottle be left open, ſuppoſing the ſolution of the metal to be continuing, and the flame of a candle applied to the mouth of the containing veſſel; the phlogiſton, which is continually diſengaging and forming vapors, but freely and without condenſation, will continue to burn in ſuch a manner, that a light-bluiſh flame will be ſeen at the mouth of the veſſel, ſuch as the flame of phlogiſton always is when this is not in an oily ſtate.

Although theſe experiments are generally made by means of a ſolution of filings of iron in vitriolic acid, I doubt not that, by employing proper management, ſimilar vapors might be produced from other imperfect metals, eſpecially thoſe which moſt eaſily part with their phlogiſton when diſſolved by acids, as tin, zinc, and regulus of antimony; and I doubt not that if theſe metallic vapors were collected in a ſufficient quantity in a cloſe place, where the air was not renewed, that they would produce the ſame fatal accidents as theſe called damps.

All theſe conſiderations induce us to believe, that moſt of theſe noxious ſubterranean vapors are nothing but phlogiſton diſengaged from certain ſubſtances, and circulating within the earth. It proceeds from bitumens and from ſulphur, which undergo different alterations and decompoſitions.

Almoſt all chemiſts and metallurgiſts agree in believing, that mineral exhalations contribute to the production of metals. This opinion is ſo much more probable, that, as phlogiſton is one of the principles of metals, (if it be true that theſe mineral exhalations are nothing elſe than phlogiſton) and as this principle is then in ſtate of vapor, and conſequently much divided, perhaps reduced to its ſmalleſt integrant particles, it is then in its moſt favorable ſtate for combination: it is therefore probable, that when theſe exhalations meet earths diſpoſed to receive them, they combine more or leſs intimately with theſe earths, according to their nature. Perhaps this is the chief operation of the grand myſtery of metalliſation. *See* METALS and PHLOGISTON. *(m)*

CCXX. DECANTATION. By this word is meant the ſeparating of a clear liquor from a ſediment, by pouring it gently.

CCXXI. DECOCTION. This word is applied to ſignify either the action of boiling a ſubſtance in water, or the water itſelf in which the ſubſtance has been boiled.

Decoction is only applicable to matters containing ſome principles ſoluble in water; ſuch, particularly, are vegetable and animal matters; and this operation is rather uſed for the purpoſes of medicine than of chemiſtry.

It is nevertheleſs very neceſſary to know well the nature and principles of ſubſtances ſubjected to decoction, that it may be properly managed, and that the principles with which the water becomes impregnated may be known.

Theſe principles muſt evidently be ſuch as are not ſufficiently volatile to riſe with the heat of boiling water, if the decoction ſhall be long continued.

Hence it follows, that plants, or other matters containing volatile principles, cannot be proper ſubjects of decoction, when theſe principles are required. In this caſe the matters may be infuſed with water in cloſe veſſels without heat, or with a heat leſs than that of boiling water.

(*m*) The damps or vapors mentioned in this article are of two kinds, *inflammable* and *uninflammable*. The inflammable kind is probably, as the author believes, ſimilar to the vapors produced by the ſolutions of iron, zinc, tin, and perhaps of other metallic ſubſtances in vitriolic and marine acids. *See* AIR (FIXABLE). This vapor is chiefly found in coal mines, and ſometimes in lead mines, as in thoſe of Mendip hills. Like the inflammable vapor of metallic ſolutions, it is lighter than atmoſpherical air, and conſequently floats chiefly near the roofs of mines: miners, therefore, when it is accidentally inflamed, or when they purpoſely ſet fire to it, to deſtroy it, lie flat on the ground, and thus eſcape burning. This inflammable vapor may perhaps be produced by the decompoſition of pyritous matters, with which moſt mines, eſpecially coal mines, abound. In this decompoſition of pyrites expoſed to air and moiſture, the vitriolic acid of the ſulphur attacks and diſſolves the iron, while the inflammable principle of the ſulphur is diſengaged, and forms this vapor.

The *uninflammable vapors* of mines and ſubterranean places are much more noxious than the former. They ſeem to be ſimilar to the uninflammable vapors produced by the combuſtion of inflammable bodies, as of charcoal, and by fermenting and eſferveſcing ſubſtances. *See* AIR (FIXABLE). Like theſe, they are noxious to animals, extinguiſh flame, and are heavier than atmoſpherical air; for they are chiefly placed at the bottom of the pits in which they are found: accordingly, in the cavern near Pyrmont, mentioned in the text, a man may ſtand upright without any other inconvenience than an uncommon heat of his lower extremities, but he cannot without danger keep his head bent down. The ſymptoms attending perſons expoſed to ſuch vapors ſhew ſufficiently that they are not noxious merely by interception of common air, but by ſome quality which almoſt inſtantly affects and deſtroys the powers of animal life. Some perſons digging in a cellar in Paris were found dead, ſtiff as ſtatues, with open eyes, and ſtanding in the poſture of digging. At Chartres, in France, a perſon going down into a cellar into which a baker had been uſed to throw hot embers from his oven, was inſtantly killed; and when his body was opened, his lungs were found ſpotted with black marks; his inteſtines ſwoln, red and inflamed; and the muſcles of his legs, thighs, and arms, ſeemed to be ſeparated from each other and from the adjacent parts. *See Bomare's Dict. d'Hiſtoire Naturelle, at the word* EXHALAISON.

But on the contrary, when it is not intended to preſerve the volatile parts, or when the matters contain none that are volatile, then decoction may be employed. It even becomes neceſſary when the matters to be treated are ſolid, and of a compact and cloſe texture; becauſe then the water could not extract its principles without a boiling heat.

Moſt ſoft animal matters, as fleſh, tendons, ſkins, may be boiled conveniently in water; becauſe they contain no principle volatile with a boiling heat. Water extracts from them nothing but a gelatinous ſubſtance, and ſome oily parts which float on the ſurface of the water.

Decoction is the only method by which all the gelatinous ſubſtance of the ſolid parts of animals, as bones and horns, can be extracted.

All vegetable matters which are inodorous, and particularly thoſe which are hard, as roots, barks, are generally boiled when an extraction of their principles by water is required.

However, many of theſe ſubſtances ought not to be boiled; thoſe particularly, the principles of which, when extracted by water, ſuffer ſome change by a continued heat. Peruvian bark, for inſtance, which is inodorous, and contains nothing volatile, ſeems capable of being treated without any inconvenience by boiling; nevertheleſs, Mr. Beaumé obſerves, in his Elements of Pharmacy, that the infuſion of this bark made without heat really contains more of its principles than the decoction. The cauſe of this is, that water extracts from bark not only the ſubſtances of which it is naturally a menſtruum, ſuch as the gummy and extractive matters, but alſo a conſiderable quantity of reſinous ſubſtance, which keeps well diſſolved in the water by means of the former matters, till it is expoſed to heat, and then it immediately ſeparates and precipitates.

Many other vegetable matters exhibit the ſame phenomenon; therefore a general rule may be eſtabliſhed, that decoction ought not to be employed but when abſolutely neceſſary, that is, when the ſame principles or the ſame quantities of theſe principles cannot be obtained by an infuſion, and that without heat, if it can be ſo done, conſidering that the proximate principles of vegetables are generally ſo delicate, and ſo ſuſceptible of change and decompoſition, that frequently the moſt gentle heat changes much their nature and properties. *See* EXTRACTS.

CCXXII. **DECOMPOSITION *of* BODIES.** The chemical decompoſition of bodies conſiſts in the diſunion and ſeparation of their principles and conſtituent parts.

This decompoſition ought neceſſarily to be diſtinguiſhed from a mere mechanical diviſion, as the following reflections will ſhew.

All bodies in general, or portions of any matter, may be conſidered as compoſed of parts ſeparable from each other.

We cannot, for inſtance, conceive an atom of matter ſo ſmall, but that this atom may be conſidered as diviſible into parts ſtill ſmaller; and this undoubtedly has given the idea of the infinite diviſibility of matter, a ſubject which we do not mean to examine here, becauſe it does not belong to chemiſtry; beſides that, it is like all thoſe in which the conſideration of infinity is concerned, that is, an abſurdity ſeems to be joined with evidence.

As chemiſtry is a ſcience ſolely founded on experience, we ſhall confine ourſelves to what experience teaches concerning the diviſibility of bodies.

But we are certain that bodies may be very ſoon reduced to ſo ſmall parts that we cannot further divide them, from the deficiency of our ſenſes and of our inſtruments.

One thing is very remarkable in this diviſion, called mechanical, becauſe it is performed by cutting or bruiſing inſtruments; this is, that however ſmall the parts be into which it reduces bodies, theſe parts are always entirely of the ſame nature as the body from which theſe parts were taken. Theſe ſmall parts of bodies are called their integrant parts. Thus, for example, the ſmalleſt atoms into which iron, ſalt, reſin, or other ſubſtance, can be mechanically divided, have all the ſame properties, excepting quantity, which the maſs had before the diviſion.

Hence we ought to conclude, that this mechanical diviſion cannot ſeparate bodies but into homogeneous parts, or parts of the ſame nature: and if we had no other method of dividing bodies, the compounds would always remain ſuch as nature offers to us, without cauſing any other change than a diminution of quantity.

The ſame thing would happen, if all natural bodies were equally ſimple, or equally compounded. But all chemical experiments ſhew, that in this reſpect there is a very great diverſity.

Some bodies are ſo ſimple that no change can be produced upon them by any effort of art. Theſe are called by chemiſts elements, or primitive principles. But theſe ſimpler bodies, the parts of which are evidently more ſmall and fine than thoſe of bodies leſs ſimple, become in the hands of chemiſts inſtruments capable of dividing theſe latter much further than can be done by mechanical inſtruments. Theſe ſimple bodies are capable of dividing molecules, which would be ſtill imperceptible by our ſenſes, although they were much larger than they are when they have undergone this inviſible diviſion.

To illuſtrate this by an example. Let us ſuppoſe a metallic maſs compoſed of mercury and gold, in ſuch proportion that no mercury can be forced out from the maſs by expreſſion, which is a mechanical method. I ſay then, that the mechanical diviſion which could be made of this compound, would only ſeparate it into ſmaller and ſmaller molecules, each of which would be of the ſame nature as the original maſs, that is to ſay, compoſed of an equal proportion of mercury and gold.

If indeed we had inſtruments and ſenſes ſufficiently fine, we might at length come to molecules, each of which would be compoſed of one atom of mercury and gold, which by one diviſion more would be ſeparated into two atoms, one of each of the two metals diſtinctly. Thus we might obtain the mercury and the gold ſeparately, and conſequently effect a decompoſition of the compound ſubſtance ſubjected to this mechanical diviſion: but the impoſſibility of ſuch a diviſion is ſufficiently demonſtrated.

Yet what mechanical inſtruments cannot do, fire, which is one of thoſe ſimple bodies we have mentioned, is capable of performing. The primary parts of this element, much finer than thoſe of gold or of mercury, become in the hands of chemiſts inſtruments inconceivably fine, which effect a ſeparation of mercury from gold, conſequently reduce to its elements or principles the compound

pound which has been ſubjected to their action, and thus analyſe or chemically decompoſe it. *See* ANALYSIS.

CCXXIII. DECREPITATION. By decrepitation is meant the quick ſeparation of the parts of a body, occaſioned by a ſtrong heat, and accompanied with noiſe and crackling. This effect is moſt frequently produced by water contained betwixt the parts of a decrepitating body, when theſe parts have a certain degree of adheſion together. This water being quickly reduced into vapors by the heat ſuddenly applied to it, rarefies and burſts with noiſe the parts which compreſs it.

The bodies moſt ſubject to decrepitation are certain ſalts, ſuch as *common ſalt*, *vitriolated tartar*, *nitre of lead*, the decrepitation of all which proceeds from the water of their cryſtallization, *clays* which are not perfectly dry, and *flints*.

CCXXIV. DELFWARE. This is a kind of pottery of baked earth, covered with an enamel or white glazing, which gives it the appearance and neatneſs of porcelain.

Some kinds of this enamelled pottery differ much from others, either in their ſuſtaining ſudden heat without breaking, or in the beauty and regularity of their forms, of their enamel, and of the painting with which they are ornamented.

In general, the fine and beautiful enamelled potteries, which approach the neareſt to porcelain in external appearance, are at the ſame time thoſe which leaſt reſiſt a briſk fire. Again, thoſe which ſuſtain a ſudden heat are coarſe, and reſemble common pottery.

The baſis of this pottery is clay, which is to be mixed when too fat with ſuch a quantity of ſand, that the earth ſhall preſerve enough of its ductility to be worked, moulded, and turned eaſily, and yet that its fatneſs ſhall be ſufficiently taken from it, that it ſhall not crack or ſhrink too much in drying or in baking.

Veſſels formed of this earth muſt be dried very gently to avoid cracking. They are then to be placed in a furnace to receive a ſlight baking, and which is only meant to give them a certain conſiſtence or hardneſs. And, laſtly, they are to be covered with an enamel or glazing, which is done by pouring upon the veſſels thus prepared, the enamel which has been ground very fine and diluted with water.

As veſſels on which the enamel is applied are but ſlightly baked, they readily imbibe the water in which the enamel is ſuſpended, and a layer of this enamel adheres to their ſurface. Theſe veſſels may then be painted with colors compoſed of metallic calxes mixed and ground with a fuſible glaſs. When they are become perfectly dry, they are to be placed in the furnace included in caſes of baked earth, called *ſeggars*, and expoſed to a heat capable of fuſing uniformly the enamel which covers them.

This heat given to fuſe, the enamel being much ſtronger than that which was applied at firſt to give ſome conſiſtence to the ware, is alſo the heat neceſſary to compleat the baking of it. The furnace and the colors uſed for painting this ware are the ſame as thoſe employed for porcelain. *See* PORCELAIN.

The glazing, which is nothing but white enamel, ought to be ſo opake as not to ſhew the ware under it. Many receipts for making ſuch enamels may be found in Neri's Treatiſe on the Art of Making Glaſs, with Kunkel's Notes, and in the Encyclopedia, both which books may be conſulted on this ſubject. We ſhall only obſerve in general, that all theſe enamels for delf-ware are compoſed of ſand or flints, vitrifying ſalts, calx of lead, and calx of tin; and that the ſand muſt be perfectly vitrified ſo as to form a glaſs conſiderably fuſible. Somewhat leſs than an equal part of alkaline ſalt, or twice its weight of calx of lead, is requiſite to effect ſuch vitrification of ſand. The calx of tin is not intended to be vitrified, but to give a white opake color to the maſs; and one part of it is to be added to three or four parts of all the other ingredients taken together.

From theſe general principles, various enamels may be made to ſuit the different kinds of earths to which they are to be applied.

To make this enamel, lead and tin are calcined together with a ſtrong fire, and the ſand is alſo to be made into a fritt with the ſalt or aſhes. The whole is then to be well mixed and ground together. This matter is then to be placed under the furnace, where it is melted and vitrified during the baking of the ware. Then it is to be ground in a mill, and applied as we have directed. *See* CLAY, POTTERY, PORCELAIN, *and* VITRIFICATION.

CCXXV. DELIQUESCENCE. We underſtand by deliqueſcence the property which certain bodies have to attract moiſture from the air, and of becoming thereby liquid.

This property is never found but in ſaline ſubſtances, or in matters containing them. It is cauſed by the great affinity which ſaline ſubſtances have with water. Hence, the more ſimple theſe ſubſtances are, the more alſo they are deliqueſcent. Acids, for inſtance, and certain alkalis, which are the moſt ſimple of ſaline ſubſtances, are alſo the moſt deliqueſcent. Mineral acids are ſo deliqueſcent that they ſtrongly imbibe moiſture from the air, although they are already mixed with a ſufficient quantity of water to be fluid. For this purpoſe it is ſufficient that they only be concentrated to a certain degree.

Many neutral ſalts are deliqueſcent, chiefly thoſe whoſe baſes are not ſaline ſubſtances. Their acids are but imperfectly ſaturated; and although they do not give the ſame marks of acidity as when quite diſengaged, they may be conſidered as ſtill poſſeſſing enough of their activity to exerciſe it on the moiſture of the circumambient air. This proves that the acids of neutral deliqueſcent ſalts are in an intermediate ſtate betwixt that of an acid quite diſengaged, and that of one perfectly ſaturated and combined.

All the phenomena which ſalts preſent relatively to their deliqueſcence, are ſo many proofs of what we have affirmed on this ſubject.

Salts formed by vitriolic acid with fixed or volatile alkalis, earths, or metallic ſubſtances, are not deliqueſcent; although this acid be the ſtrongeſt of all, and which, when diſengaged, moſt powerfully attracts moiſture from the air. But its greater ſtrength is the real cauſe of its forming ſo complete and intimate combinations with theſe ſeveral ſubſtances as to form neutral ſalts which are not deliqueſcent.

The nitrous and marine acids form with abſorbent earths and certain metallic ſubſtances, particularly with iron and copper, deliqueſcent ſalts, from the weakneſs of the union which they contract with theſe matters. Theſe acids form with ſilver, mercury, lead, and biſmuth, ſalts which are not deliqueſcent, becauſe they combine more intimately and completely with theſe latter metals.

Singular phenomena are preſented by vegetable acids relatively to the deliqueſcence of the neutral ſalts formed by them. The acid of vinegar united with fixed vegetable alkali forms a very deliqueſcent ſalt, called *terra foliata tartari.* The ſame acid forms with copper a ſalt that is not deliqueſcent, as we ſee in the inſtance of *cryſtals of copper.* Theſe effects are directly contrary to thoſe produced by the nitrous and marine acids united with the ſame ſubſtances; for theſe acids form with fixed vegetable alkali ſalts which are not deliqueſcent, and with copper ſalts which are very deliqueſcent.

The acid of tartar, which when diſengaged is in a concrete ſtate, and far from being deliqueſcent, ſince it is ſcarcely ſoluble in water, forms with iron (another ſubſtance ſtill leſs ſoluble) a very deliqueſcent ſoluble tartar, known by the name of *tartariſed tincture of iron.*

Many reſearches and experiments remain yet to be made to explain entirely the cauſes of theſe ſingular effects. But probably the deliqueſcence or oppoſite quality of ſalts will be found to depend on the ſtate of their acids, as we have already ſaid.

The fixed vegetable alkali is deliqueſcent, the mineral is not. The cauſe of this undoubtedly is, that the ſaline principle of this latter is combined more intimately, or with a greater quantity of matter not ſaline, than that of the former, as the other properties of theſe two alkalis indicate. *See* Alkali.

Fixed vegetable alkali treated with quicklime becomes more deliqueſcent. Volatile alkalis, which are naturally not deliqueſcent, become by treatment with quicklime deliqueſcent. We cannot explain theſe phenomena without ſuppoſing that quicklime takes from alkalis in general a portion of oily or other matter, which binds and ſaturates their ſaline principle, when in their natural ſtate.

The dry extracts of almoſt all vegetable matters eaſily moiſten in the air. But they certainly poſſeſs this property ſo much more evidently, as a greater quantity of earthy or reſinous matter, which is always depoſited during the evaporation, has been previouſly ſeparated from their infuſions and decoctions.

Before we finiſh this article we ought to obſerve, that ſome bodies which are not deliqueſcent attract moiſture from the air, and even become liquid, that is, if they be ſaline or ſoluble in water. This happens when bodies are much colder than the air to which they are expoſed. The reaſon of it is, that the moiſture contained in the air being always in the ſtate of inſenſible vapors, is condenſed by the cold of the bodies it touches, and is collected in drops. This effect is very different from a true deliqueſcence; but it deſerves to be taken notice of, to prevent miſtakes in experiments.

Laſtly, we muſt remark, that ſome bodies, after having been a long time expoſed to the air, may remain apparently dry, although they really be in the diſpoſition of deliqueſcent bodies, that is, attract much moiſture from the ambient air. Such, for inſtance, is quicklime, which imbibes from the air its equal weight of moiſture, and retains, notwithſtanding, its dry and powdery appearance. This proceeds from the great quantity of earthy parts with which thoſe parts of the quicklime are mixed, which may be conſidered as deliqueſcent, although, in fact, they do not reſolve into a liquor.

CCXXVI. **DELIQUIUM.** This term is frequently employed by chemiſts to characterize a body which is reſolved into a liquor by expoſure to air. In this ſenſe they ſay the deliquium of a ſalt, as of ſalt of tartar, for inſtance. This word is alſo frequently uſed inſtead of deliqueſcence. Thus we ſay, that a ſalt falls into a deliquium, to ſignify that it is deliqueſcent.

CCXXVII. **DEMI-METAL.** The ſame as SEMI-METAL; *which ſee.*

CCXXVIII. **DEPHLEGMATION.** Dephlegmation is an operation by which the ſuperabundant water of a body is taken from it, and it is principally effected by evaporation or diſtillation. Dephlegmation is alſo called concentration, particularly when acids are the ſubject. *See* CONCENTRATION.

CCXXIX. **DETONATION.** By the word *detonation* chemiſts underſtand an exploſion with noiſe made by the ſudden inflammation of ſome combuſtible body. Such are the exploſions of *gun-powder*, *fulminating gold*, and *fulminating powder*. As nitre is the cauſe of moſt exploſions, the word *detonation* has been appropriated to the inflammation of the acid of this ſalt with bodies containing phlogiſton, and it is frequently given to thoſe inflammations of nitrous acid which are not accompanied with exploſion. Thus *nitre* is ſaid to detonate with ſulphur, with coals, with metals, although in the ordinary method of making theſe operations, that is, in open crucibles, and with ſmall quantities of detonating ſubſtances, the nitre does not truly explode.

CCXXX. **DETONATION of NITRE.** The detonation of nitre is one of the moſt important phenomena of chemiſtry. It conſiſts in the inſtantaneous inflammation and decompoſition of the acid of nitre, when it immediately touches combuſtible bodies, the phlogiſton of which is ignited, or when the acid is ignited.

By two methods then may nitre, or rather its acid, be inflamed. The firſt method is by applying it to a red-hot combuſtible body; and the ſecond is by making the acid itſelf red-hot, and applying a combuſtible body to it in that ſtate.

A very neceſſary remark is, that nitre cannot detonate without the concurrence of theſe circumſtances now mentioned. Nitre may be made red-hot, or of any degree of heat, without ſhewing any ſign of inflammation, provided it does not touch any inflammable matter.

On the other ſide, nitre may be heated, and a combuſtible body applied to it without any inflammation. For this purpoſe, the nitre need only be not ſufficiently hot to kindle the inflammable bodies applied to it. Meſſrs. Macquer and Beaumé ſhow, in their Courſe of Chemiſtry, an experiment which clearly proves this truth. Some nitre is put into a crucible, and there completely fuſed by a heat juſt ſufficient for that purpoſe; when a black coal is thrown into this fuſed nitre, no inflammation ariſes, becauſe the nitre may be melted with a degree of heat which is not ſufficient to kindle combuſtible bodies; and this degree of heat is neceſſary for the ſucceſs of the experiment.

But when nitre is red-hot, and a coal is applied to it, kindled, or not kindled, then it is inflamed with violence, and makes the coal burn rapidly. The ſame event happens when nitre is thrown upon burning coals. This inflammation laſts while theſe two ſubſtances touch, and any acid remains in the nitre. During this detonation a conſiderable ſmoke riſes; but this ſmoke contains no acid, as the experiment of the clyſſus of nitre made in cloſe veſſels ſufficiently proves. *See* CLYSSUS *of* NITRE.

When all the nitrous acid is thus burnt, and no longer any inflammation is excited, although more coals are added, if we examine what remains in the crucible, we ſhall find that it is the fixed alkali which was the baſis of the nitre. This alkali is called *fixed* or *alkaliſed nitre.* See *theſe words, and* Alkali (Fixed Vegetable).

The detonation may be rendered more eaſy and ſudden by making the nitre touch the inflammable matter in a greater number of parts; ſo that when theſe two ſubſtances are divided into very minute parts, which are well mixed and interpoſed betwixt each other, the detonation is almoſt inſtantaneous, and is as ſtrong as it can be made. When the ſubſtances are thus prepared, they may be at once inflamed by a ſmall ſpark of ignited matter; becauſe the ignition is very quickly and almoſt inſtantaneouſly communicated by ſmall intervals. From the accurate mixture of the two detonating ſubſtances proceeds the great force and violence of *gun-powder.* *See* Powder (Gun).

Hence we may learn to avoid the violence of detonations in chemical operations, by mixing very imperfectly the nitre with the combuſtible ſubſtances.

Let us now conſider what paſſes in the detonation of nitre. Mr. Macquer, in his Elements of Chemiſtry, conjectures that the detonation of nitre, which is, properly ſpeaking, the inflammation of the nitrous acid, cannot take place, unleſs a combination be previouſly formed betwixt this acid and the phlogiſton of the combuſtible ſubſtance uſed for the detonation; that this combination is entirely ſimilar to that of vitriolic acid with phlogiſton when ſulphur is formed; and that, in the preſent inſtance, *a nitrous ſulphur* is produced; but that this ſulphur is infinitely more combuſtible than the vitriolic ſulphur, for a reaſon we ſhall ſoon ſee, and even ſo combuſtible, that it cannot exiſt an inſtant without being entirely burnt; hence it is inflamed with extreme rapidity and violence as ſoon as it is formed.

The moſt eſſential circumſtances attending the detonation of nitre concur in rendering this opinion probable, that is, to eſtabliſh the preliminary exiſtence of this nitrous ſulphur.

Firſt, vitriolic ſulphur cannot be formed by vitriolic acid engaged with a fixed alkali, unleſs this acid be deprived of all the water ſuperabundant to its ſaline eſſence, and in a dry ſtate, when it is applied to phlogiſton.

In the ſecond place, to effect this combination, a degree of heat equal to that of ignition muſt be applied.

Thirdly, as in ſulphur not a particle of oil exiſts, but the vitriolic acid is united to pure phlogiſton, as the illuſtrious Stahl has fully demonſtrated; if, therefore, an inflammable matter, which is in an oily ſtate, be uſed for the formation of ſulphur, it muſt be firſt decompoſed, and reduced to the ſtate of coal, before the ſulphur can be produced. *See* Sulphur. But theſe are preciſely the ſame conditions which are neceſſary for the detonation of nitre; for ſince the acid of nitre cannot detonate unleſs it be ignited, it muſt be evidently deprived of all the water ſuperabundant to its ſaline eſſence.

In the ſecond place, experience ſhews that nitre cannot detonate with any matter which is in an oily ſtate; for if nitre be ignited in a crucible, and oil, reſin, fat, or other inflammable matter of this kind be added to it, no detonation will happen while the inflammable matter remains in its oily ſtate, or till it be burnt, decompoſed, and reduced to a coal; then the detonation commences, and is always proportionable to the quantity of coal produced by the inflammable matter.

Some ſubſtances, the phlogiſton of which is certainly in an oily ſtate, ſuch as tartar, ſaw-duſt of wood, and others of this kind, do indeed detonate with nitre almoſt as readily as powder of charcoal; but we may eaſily perceive that the cauſe of this is, that the oil of theſe ſubſtances, being divided by the interpoſition of a large quantity of incombuſtible matters, may be exceedingly ſoon reduced to the ſtate of coal by the heat of ignition.

Several facts intimately connected with the detonation of nitre may be naturally deduced from this theory, and conſequently become additional proofs of it.

Let nitrous acid, as much dephlegmated as poſſible, be poured upon black coals, as dry and hot as they can be made, under a red-heat, no detonation or inflammation will enſue. This is not ſurpriſing, ſince all the neceſſary conditions for the production of nitrous ſulphur are wanting here, and ſince in ſimilar circumſtances ſulphur could not be formed by vitriolic acid.

If an ardent coal be plunged into the ſtrongeſt nitrous acid, a detonation begins at the ſurface of the coal, which very ſoon ceaſes; the coal is extinguiſhed, becomes black, and is not affected by the acid. The ſhort detonation upon the ſurface of the coal may be conſidered as accidental, and not belonging to the experiment; otherwiſe the detonation would continue while the acid laſted. This detonation can only be cauſed by a ſmall quantity of nitre, formed inſtantaneouſly by the acid uniting with ſome ſmall portion of alkaline ſalt contained in the aſhes of the coal, which happen to lie on its ſurface: therefore, when this ſmall quantity of nitre is conſumed, the coal is extinguiſhed, and the detonation ceaſes; and all this ought to happen becauſe the moſt dephlegmated nitrous acid contains always a conſiderable quantity of water ſuperabundant to its ſaline eſſence; and as it is not in the preſent experiment retained or fixed by any baſis, it diſſipates in vapors before it can be totally dephlegmated by the heat of the ardent coal: hence in this experiment no nitrous ſulphur can be formed; neither can vitriolic acid form vitriolic ſulphur in ſimilar circumſtances, but only volatile ſulphureous acid.

From theſe facts we may conclude, that nitrous acid, while free, that is, not engaged in any baſis, cannot ever contract with phlogiſton ſuch an union, as that a ſulphureous compound, or nitrous ſulphur, ſhall be formed; not only becauſe of the ſuperabundant water it always contains, but alſo becauſe, from its want of fixity, it cannot be deprived of this ſuperabundant water in the very act of combination. We may therefore affirm as a general and eſtabliſhed principle, that diſengaged nitrous acid is not capable of detonation. If then this pure acid inflames oils mixed with it, this inflammation proceeds from a very different cauſe than the true detonation of nitre, as Mr. Macquer has ſhewn in his Elements of Chemiſtry; nitre and diſengaged nitrous acid being very different from each other, particularly with regard to detonation. *See* INFLAMMATION *of* OILS.

What we have ſaid on this ſubject clearly ſhews why combinations of nitrous acid with certain baſes form nitres ſuſceptible of a ſtrong detonation, while others of the ſame acid with different baſes detonate weakly or not at all; theſe differences depending on the greater or leſs adheſion of the nitrous acid with its baſis. All thoſe nitrous ſalts in which the acid is ſo firmly fixed and retained by its baſis, that it may be entirely dephlegmated and ignited, are ſuſceptible of a ſtrong detonation; ſuch are *ordinary nitre, cubic nitre, nitrous ammoniacal ſalt, nitres of ſilver, of mercury, of lead, and of biſmuth*; of all which ordinary nitre detonates moſt violently, and is the only one of which good gun-powder can be made; becauſe the fixed vegetable alkali, which is the baſis of nitre, has a ſtronger adheſion to nitrous acid than any other of the ſubſtances ſoluble by this acid.

On the contrary, all combinations in which nitrous acid is only weakly united, do not detonate, or very weakly. Such are *nitres with baſis of calcareous earths, of copper, of iron, of tin, of regulus of antimony*; theſe being all nitrous ſalts in which the acid adheres weakly; as their deliqueſcent quality, and the facility with which fire detaches this acid from them, ſufficiently ſhew.

We ſhall now examine what happens in the very act of the detonation of nitre, or rather in the deflagration of nitrous ſulphur. We have ſeen that this ſulphur is formed in the ſame circumſtances as vitriolic ſulphur; but if theſe two compounds reſemble each other in the manner of their production, they differ entirely in the phenomena of their combuſtion.

Vitriolic ſulphur burns very weakly; produces a flame which is very little luminous; requires for the continuance of its burning a conſtant ſupply of new air; and its acid undergoes no change by this combuſtion. Nitrous ſulphur, on the contrary, appears incapable of exiſting an inſtant without burning. Its vivid, dazzling flame, accompanied with noiſe, reſembles the flame of a fire ſtrongly actuated by a blaſt of air; it needs not the contact of external air; it burns with the ſame violence and rapidity in cloſe veſſels; no obſtacle is capable of containing it; and if it be confined, it burſts with a terrible noiſe the ſides of the confining veſſels; laſtly, after its combuſtion no trace is found of its acid.

What can be the cauſe of ſo conſiderable differences? and how are ſo ſingular phenomena produced? We cannot do better than adopt entirely the theory of Stahl. This great chemiſt has explained all theſe effects in a manner the moſt ſatisfactory, and the moſt conformable to the principles of rational chemiſtry.

Stahl conſiders nitrous acid as compoſed of a watery principle, and of an earthy principle, as well as all other acids; but he alſo admits a third element to enter into this acid, by which it is characteriſed, and by which it differs from vitriolic acid. This third principle of nitrous acid is phlogiſton; but this principle is ſo proportioned and combined with the other two, that nitrous acid is not inflammable while alone, even when it is ignited; but if a new quantity of inflammable principle unites with nitrous acid, (which happens in the production of nitrous ſulphur) then the proportion of this principle being encreaſed, it accordingly aſſumes all the properties, and particularly the inflammability, which is eſſential to it. Hence nitrous acid cannot be combined with a body containing phlogiſton, ſo diſpoſed as to be capable of forming with it an intimate union; that is, a nitrous ſulphur, without producing an inflammation. If, then, phlogiſton united intimately with vitriolic acid forms vitriolic ſulphur, which is much leſs inflammable, this happens becauſe phlogiſton is not one of the principles of vitriolic acid, and does not enter into its combination, as it enters into that of nitrous acid.

From this cauſe alſo, namely the exiſtence of phlogiſton in nitrous acid, as a principle, Stahl deduces the deſtruction or total decompoſition of this acid, when it is inflamed, and this he does upon good grounds; for then not only the phlogiſton which is combined ſuperabundantly with nitrous acid is inflamed, but alſo this ſuperabundant phlogiſton, finding itſelf mixed and confuſed with the phlogiſton which is a principle of nitrous acid, takes this along with it in its inflammation, and the whole is entirely conſumed.

This being eſtabliſhed, we ought not to wonder that no nitrous acid is found after the detonation; for every compound body, from which one of its principles is taken, is thereby neceſſarily decompounded. If the inflammable principle of this acid could be conſumed without deſtroying the connexion of the other principles, we ſhould not indeed find after detonation any nitrous acid, becauſe the phlogiſton, its diſtinguiſhing principle, would have been taken from it; but as, according to Stahl, the union of the two principles, the watery and the earthy, is ſufficient to conſtitute an acid, we ſhould ſtill find an acid ſubſtance of a different nature from nitrous acid, nearly in the ſame manner that we find pure vitriolic acid after the portion of phlogiſton which had conſtituted it volatile ſulphureous acid has been taken from it: but things paſs quite otherwiſe in the inflammation of nitrous acid; not a veſtige remains of this, or of any other acid; nothing is found again but earth and water. This ſhews the connexion of the principles of nitrous acid to be ſuch, that one of its conſtituent parts cannot be taken from it without an entire disjunction of the others; ſo that after its inflammation, it does not exiſt neither as nitrous, nor as any other acid.

We may eaſily perceive how much theſe facts, and the conſequences reſulting from them, give probability to the opinion of Stahl, who thinks that every acid, in general, reſults from an union of a watery with an earthy principle; and that the particular and ſpecific properties of the ſeveral acids are cauſed by ſome other principle, which enters into their combination with theſe two eſſential conſtituent parts.

The exploſion accompanying the detonation of nitre, and which is ſo much more violent as the matters have been more perfectly mixed, and more cloſely compacted, proceeds from a great and ſudden dilatation of ſome very expanſible body. Moſt natural philoſophers have attributed it to air contained in nitre, and in matters with which the nitre detonates; becauſe air included and rarefied is capable of producing, and does produce, very violent exploſions: nevertheleſs, we muſt obſerve, that none of the exploſions of air are equal in violence to thoſe of gun-powder, of fulminating-powder, and of fulminating-gold, which are certainly effects of the inflammation of nitrous acid.

Theſe conſiderations alſo incline us to adopt the opinion of Stahl on this phenomenon. This chemiſt thinks, that theſe exploſions ought not to be attributed to the air, but to the water of the nitre, or rather of its acid; which is capable of producing much more violent exploſions than thoſe of air, when a ſtrong heat, ſuch as that of red-heat, is ſuddenly applied to it, as happens in the detonation of nitre. *See* Water.

The ſame chemiſt goes farther. He advances, not without much probability, that water, the aggregation of which is entirely broken, acquires the property of air. Upon this ſuppoſition we may well explain why nitre is capable of burning with combuſtible ſubſtances, without the acceſs of air, and in cloſe veſſels. The reaſon of this is, that it contains in its own ſubſtance a matter which diſengages itſelf from it while it burns, and which, if it is not air, has as well, or better, the property of maintaining combuſtion. The flame iſſuing from nitre when made to detonate ſo ſlowly that it can be obſerved, ſeems to prove what we have advanced on the ſubject; for it has, as we have ſaid, all the appearance of the flame of a body excited ſtrongly by a blaſt iſſuing from its own centre. *(n)*

Nitre detonates with ſulphur, and with thoſe metallic ſubſtances the phlogiſton of which is ſo diſpoſed that it can eaſily burn; ſuch are iron, tin, zinc, and others of this nature. This detonation has nothing peculiar: it muſt happen not only from the combuſtibility of the phlogiſton of theſe ſubſtances, but alſo becauſe this phlogiſton is not in the ſtate of oil. What we have ſaid concerning the detonation of nitre by coals, is applicable to thoſe which are now treated. However, attention muſt be given to the other principles of theſe ſubſtances, and to the greater or leſs quantity, and degrees of combuſtibility of their phlogiſton.

CCXXXI. DEW. Formerly this name was given to the phlegm that roſe firſt in the diſtillation of ſeveral ſubſtances. Thus the *dew of vitriol*, *the dew of honey*, were watery liquors which roſe firſt when theſe ſubſtances were diſtilled.

CCXXXII. DIAMOND. Diamonds are ſtones of the vitrifiable kind, which are found naturally cryſtallized, nearly as rock-cryſtal is, in form of ſix-ſided priſms, each extremity of which is terminated by a pyramid alſo of ſix ſides. Some diamonds, however, are differently cryſtallized.

Diamonds are the moſt beautiful and the deareſt of all precious ſtones. They are of different colors, particularly yellow; but the greateſt part of them are white, and amongſt theſe, the whiteſt and moſt tranſparent are of higheſt value. No ſtone is harder than the diamond; it is alſo very refractory, and even apyrous; it has all the properties of vitrifiable ſtones, with this difference, that it requires more fire, and a larger quantity of flux to produce its vitrification than any other of the ſubſtances of the ſame kind. *See* STONES (VITRIFIABLE). *(o)*

(n) The exploſion of nitre deflagrated with inflammable ſubſtances is cauſed by an elaſtic fluid, which is produced from the nitre and theſe ſubſtances by deflagration. This fluid is not the water of the nitre rarefied and converted into air; for the water of the nitre is only rarefied by the heat of the deflagration, and is afterwards by cold condenſed, forming the water called clyſſus of nitre. *See* CLYSSUS *of* NITRE. But the elaſtic fluid produced by deflagration is permanent, and not condenſible into a liquid. Mr. Robins found, by accurate experiments, that the fluid produced by firing gun-powder, when confined within a ſpace equal to that of the gun-powder which was fired, and reduced to the heat of the atmoſphere, was capable of ſuſtaining a preſſure equal to 244 times the preſſure of the atmoſphere; and that the elaſtic force of the fluid was increaſed probably about four times by the heat produced by the firing of the powder; and conſequently that it is thereby rendered capable, at the inſtant of exploſion, of ſuſtaining a preſſure nearly equal to a thouſand times the preſſure of the atmoſphere. *See* Robin's *Principles of Gunnery*.

(o) Diamonds are the moſt hard, heavy, tranſparent, and brilliant of all ſtones. They are either hexagonal priſms terminated by eight-ſided points or pyramids; or they are flat, or cubical, or rounded. Whether this difference of form be original, or adventitious, has not been determined. The firſt kind are the beſt and hardeſt, and may therefore have preſerved their original form againſt accidents better than the others, eſpecially than thoſe which are rounded, which are ſaid to be the leaſt hard, and conſequently moſt liable to have their forms altered by

CCXXXIII. DIAPHORETIC ANTIMONY. This is a white calx of antimony, made by calcining antimony with thrice its quantity of nitre. *See* Antimony.

CCXXXIV. DIGESTION. Digeſtion is an operation which conſiſts in expoſing bodies to a gentle heat, in proper veſſels, and during a certain time.

This operation is very uſeful to favor the action of certain ſubſtances upon each other; as, for example, of well calcined, dry fixed alkali upon rectified ſpirit of wine. When theſe two ſubſtances are digeſted together in a matraſs, with a gentle ſand-bath heat, the ſpirit of wine acquires a yellow-reddiſh color, and an alkaline quality. It is then called *alkaline tincture*, or *tincture of ſalt of tartar*. *See* Tincture *of* Salt *of* Tartar. The ſpirit would not ſo well acquire theſe qualities by a ſtronger and ſhorter heat.

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attrition. Diamonds are ſaid to conſiſt of laminæ or plates, and probably they have ſome uniform texture; becauſe lapidaries find that they may be poliſhed much more eaſily in one than in any other direction. This ſtone becomes luminous in the dark by expoſure during a certain time to the rays of the ſun; by heating it in a crucible; by plunging it in boiling water; or by rubbing it with a piece of glaſs. By friction it acquires an electrical property, by which it attracts the ſubſtance uſed for foils, called black maſtic, and other light matters. The author of the Dictionary ſays, that diamonds are refractory in the fire, and even apyrous. Nevertheleſs, experiments have been made, which prove that diamonds are capable of being diſſipated not only by the collected heat of the ſun, but alſo by the heat of a furnace. A diamond, by expoſure to a concave ſpeculum, the diameter of which was forty inches, was reduced to an eighth part of its weight. See *Phil. Tranſ.* No. 386. In the *Giornale de Letterati d'Italia, Tom.* viii. *Art.* 9. we may read a relation of experiments made on precious ſtones, by order of the Grand Duke of Tuſcany, with a burning lens, the diameter of which was two thirds of a Florentine ell, near the focus of which was placed another ſmaller lens. By theſe experiments we find that diamonds were more altered by ſolar heat than moſt of the other precious ſtones, although not the leaſt appearance of a commencing fuſion was obſervable. A diamond weighing thirty grains, thus expoſed during thirty ſeconds, loſt its color, luſtre, and tranſparency, and became of an opake white. In five minutes, bubbles appeared on its ſurface; ſoon afterwards it burſt into pieces, which were diſſipated; and the ſmall fragment which remained was capable of being cruſhed into fine powder by the preſſure of the blade of a knife. Neither the addition of glaſs, flints, ſulphur, metals, or ſalt of tartar prevented this diſſipation of diamonds, or occaſioned any degree of fuſion. By this heat, rubies were ſoftened, and loſt ſome of their color, but preſerved their form and weight. By addition of a third lens, a further degree of fuſion was given to rubies. Even then rubies could not be made to unite with glaſs. By having been expoſed to this heat, the ſurface of the rubies which had ſuffered fuſion, loſt much of their original hardneſs, and were nearly as ſoft as cryſtal. But their internal parts, which had not been fuſed, retained their hardneſs. Emeralds by this heat were rendered white, or of various colors, and ſoon afterwards were fuſed. They were found to have loſt part of their weight, and to be rendered leſs hard and brittle.

Experiments were alſo made by order of the Emperor Francis I. on precious ſtones, from which we find, that diamonds were entirely diſſipated by having been expoſed in crucibles to a violent fire of a furnace during twenty-four hours; while rubies by the ſame heat were not altered in weight, color, or poliſh. By expoſing diamonds during two hours only at a time, the alterations produced on them by fire were obſerved. Firſt, they loſt their poliſh, then they were ſplit into thin plates, and, laſtly, totally diſſipated. By the ſame fire, emeralds were fuſed. See *Magaſin de Hambourg*, *tom.* xviii.

Digeſtion is alſo uſed to ſoften and open certain bodies deſigned to undergo further operations, or to excite in them a certain degree of fermentation.

CCXXXV. DISTILLATION. Diſtillation is an operation by which the fluid and volatile principles of bodies may be ſeparated and collected with a convenient degree of heat.

If compounds containing volatile and fixed principles be expoſed to fire, the former being rarefied by heat will endeavor to ſeparate themſelves from the latter; and if the effort which they make for this purpoſe be ſuperior to the coheſion which they have with the fixed principles, a ſeparation will happen, and they will be diſſipated in ſtate of vapor.

The different fixity and volatility, which the ſeveral principles of almoſt every compound body have, furniſhes a very extenſive method of ſeparating and obtaining their principles. This chemiſts effect by diſtillation.

Diſtillation requires an apparatus of veſſels ſuited to the nature of the ſubſtances to be treated, and of the principles to be obtained.

If the ſubſtance to be diſtilled be very compound, very ſuſceptible of alteration by heat, and containing very volatile principles, ſuch as moſt odoriferous plants, ſpirituous liquors, and others of this nature, a veſſel muſt be uſed called an *alembic*, which muſt alſo be provided with a water-bath. *See* ALEMBIC.

As in the diſtillation made with an alembic the vapors riſe vertically, and are condenſed in the upper part of the veſſel called its *capital* or *head*, this method of diſtillation has been called *per aſcenſum*. By this method may be diſtilled all matters volatile enough to riſe with a degree of heat not exceeding that of boiling water: ſuch are the *ſpiritus rector of plants*, *ardent ſpirits*, and all *eſſential oils*.

When compound bodies are to be diſtilled, the moſt volatile parts of which require a heat ſuperior to that of boiling water, *retorts* muſt be employed; becauſe theſe veſſels may be conveniently placed either in a ſand-bath or in a naked fire, and may be ſo diſpoſed in a reverberatory furnace, that the matter which it contains ſhall be equally heated on all ſides.

The ſhape of a retort is ſuch, that principles reduced to the ſtate of vapor cannot iſſue but laterally through the neck of the veſſel, which is accordingly placed on one of its ſides. This diſtillation has thence been called *per latus*. *See* RETORT.

This ſecond method of diſtilling is very uſeful, and may be applied to obtain eſſential oils, heavy acids, eſpecially mineral acids, and ſometimes even very volatile ſubſtances; as for example, the volatile alkali from ſal ammoniac, or from animal matters which have not undergone putrefaction.

A third kind of diſtillation is called *per deſcenſum*; becauſe it conſiſts in applying the heat above the bodies whence the volatile parts are to be extricated; and by this method theſe volatile parts are obliged to deſcend into a veſſel prepared for their reception. But this method of diſtillation has many faults, is abſolutely unneceſſary, and is entirely neglected.

We may eaſily conceive what paſſes in diſtillation. Volatile ſubſtances are rendered by a ſuitable heat ſpecifically lighter, are reduced to the ſtate of vapor, and would be diſſipated, if they were not retained, and obliged to paſs into colder places, where they are condenſed and become liquors, if ſuch be their nature; or elſe they collect in ſmall ſolid particles called *flowers*, and in this caſe the operation changes its name, and is called *ſublimation*. *See* SUBLIMATION.

As diſtillation is always performed in cloſe veſſels, the matters which riſe are excluded from the acceſs of air, which accelerates the aſcent of volatile bodies. *See* AIR.

Hence diſtillations and ſublimations, which are, properly ſpeaking, only evaporations in cloſe veſſels, are more diſadvantageous than evaporations in open air. This is an inconvenience in all caſes where diſtillation may be carried on very faſt without any accident. Such, for inſtance, is the diſtillation of water alone. This inconvenience may be in a great meaſure remedied by introducing into the cucurbit a current of air by means of a ventilator, according to a method propoſed by an Engliſh chemiſt to accelerate the diſtillation of ſea-water, with a deſign to obtain by that means freſh water from it.

But in diſtillations of almoſt all other ſubſtances, this ſlowneſs occaſioned by want of air is rather uſeful than diſadvantageous; becauſe the more ſlowly a volatile ſubſtance is ſeparated from a fixed ſubſtance, the more perfect is the ſeparation. For this reaſon, when a diſtillation is required to be performed according to the rules of the art, it muſt be ſo conducted that no more heat ſhall be applied to raiſe the volatile body than is neceſſary. This management is particularly neceſſary when there is not a great difference betwixt the volatility of the principles of the body diſtilled. We have an evident example of this in all concrete oily matters. When we intend to ſeparate the acid and the oil of which theſe matters conſiſt, as theſe two principles have nearly the ſame volatility, they riſe together, and are not diſunited; ſo that the compound body paſſes in diſtillation without ſuffering any decompoſition. *See* BUTTER. Notwithſtanding the moſt careful management of moſt diſtillations, the volatile principles are ſeldom obtained perfectly free from the other principles of the compound; and therefore, to be purified, muſt be ſubmitted to new diſtillations, called *rectifications*.

We may then eſtabliſh, as general and eſſential rules of diſtillation, that no greater heat ought to be applied than is juſt neceſſary to raiſe the ſubſtances to be diſtilled; and that the ſlowneſs of the operation is no leſs advantageous than the hurrying of it too much is prejudicial.

Theſe rules ought alſo to be obſerved for ſome other very ſtrong reaſons. Such is the prevention of the breaking of veſſels, which frequently happens in thoſe of glaſs or of earthen ware when they are too ſuddenly or too ſtrongly heated, and moſt certainly happens when the vapors riſe more quickly than they can be condenſed.

Theſe accidents are chiefly occaſioned by vapors which are very elaſtic and not eaſily condenſible. Some vapors, as theſe of the ſmoking nitrous and marine acids, have theſe qualities ſo ſtrongly, that much of them is loſt, by the neceſſity of giving frequently a vent to them, by unſtopping a ſmall hole made in the balloon employed as a receiver in ſuch diſtillations, and which might be conveniently made in all receivers*.

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* *See* PLATES; where the veſſels uſed in diſtillations are repreſented.

CCXXXVI. DITTANY *of* CRETE. (p)

CCXXXVII. DIVISION. By *diviſion* we ought to underſtand that ſeparation which is occaſioned in the parts of a body by help of mechanical inſtruments.

The mechanical diviſion of bodies does indeed ſeparate them into ſmaller, homogeneous, ſimilar parts; but this ſeparation cannot extend to the primary integrant molecules of any body, and conſequently is incapable of breaking what is properly called their aggregation: alſo, no union is formed betwixt the divided and dividing bodies, in which reſpect diviſion eſſentially differs from *ſolution*.

Diviſion is not properly a chemical operation. It is only employed preparatorily to facilitate other operations, and particularly ſolution. For this purpoſe it is very uſeful, as it encreaſes the quantity of ſurface, and conſequently the points of contact of any body.

Different methods are uſed to divide bodies according to their nature. Thoſe which are tenacious and elaſtic, as horns and gums, require to be cut, raſped, or filed. Metals, becauſe of their ductility, require the ſame treatment: but as they alſo are fuſible, they may be quickly and conveniently reduced into grains ſmall enough for moſt operations, by pouring them, when melted, into water.

All brittle bodies may be reduced conveniently into fine parts by being bruiſed in a mortar with a peſtle.

Very hard bodies, ſuch as glaſs, cryſtals, ſtones, particularly thoſe of the vitrifiable kind, before they are pounded, ought to be plunged when red-hot into water, by which they are ſplit and cracked, and rendered more eaſily pulverable.

Bodies of this kind may alſo be bruiſed or ground by means of a hard and flat ſtone, upon which the matter is to be put, and bruiſed by another hard ſtone, ſo ſmall as to be held and moved upon the larger ſtone with the hand. The larger ſtone is called a *porphyry*, from its being generally of that kind of ſtone; and the operation is called *porphyriſation*. Inſtead of porphyriſation, a mill may be uſed, compoſed of a hard grit millſtone, moving round upon another ſtone o the ſame kind, which muſt be fixed: in the upper ſtone is a groove, or channel, through which the matter to be ground paſſes. By this method a ſubſtanc may be more quickly reduced to a fine powder than by porphyriſation. Bu theſe mills can be only employed for conſiderable quantities of matter, as fo manufactories of pottery and porcelain.

Theſe methods of mechanically dividing bodies are attended with ſome practical inconveniences; the moſt conſiderable of which is, that ſome parts of th dividing inſtruments are always ſtruck off, and mixed with the matter to be di

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(p) DITTANY *of* CRETE. Sixteen ounces of the leaves of this plant yield about half a dram of a ſtrong, aromatic, eſſential oil, which coagulates by cold, reſembling camphor. From an ounce of this plant Neuman obtained with water two drams and a ſcruple of extract; and from the ſame quantity, with ſpirit of wine, he obtained a dram and a half of reſinous extract. He obſerves, tha the green color of the leaves reſides in th reſin, and is extractable by ſpirit, eſpeciall after water has previouſly extracted th gummy part, ſome of which being alſo ſo luble by ſpirit along with the reſin, alte the color of the ſpirituous tincture.

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vided. This may greatly affect the operations. For inſtance, inſtruments of iron and copper furniſh coloring metallic parts, and the latter metal is hurtful to health. Porphyry is colored by a reddiſh-brown matter, which injures the color of cryſtal-glaſſes, enamels, and porcelain, made with matters ground upon this ſtone. Theſe matters, therefore, muſt be cleanſed after their porphyriſation, or elſe no inſtruments ought to be employed capable of injuring the intended operations. Thus, for the preparation of all medicines to be taken internally, no copper inſtruments, as mortars, peſtles, ought to be uſed; thoſe made of iron are preferable; and, inſtead of porphyries, mortars, grinding-ſtones, and mill-ſtones, made of hard and white ſtones, ought to be employed for ſubſtances which are to enter into the compoſition of enamels, cryſtal-glaſs, and porcelain, the whiteneſs of which is a moſt neceſſary quality.

CCXXXVIII. DOCIMASTIC ART. This name is given to the art of eſſaying, by operations in ſmall, the nature and quantity of metallic or other matters, which may be obtained from mineral or other compound bodies. The moſt important operations of the docimaſtic art are found under the words, Refining, Ores, Essays *of* Ores.

CCXXXIX. DOME. The upper piece of furnaces, and particularly of portable furnaces, is called the *dome*. It has the form of a hollow ſemiſphere or ſmall dome. Its uſe is to form a ſpace in the upper part of the furnace, the air of which is continually expelled by the fire; hence the current of air is conſiderably encreaſed, which is obliged to enter by the aſh-hole, to paſs through the fire, to ſupply the place of the air driven from the dome. The form of this piece renders it proper to reflect or reverberate a part of the flame upon the matters which are in the furnace, which has occaſioned this kind of furnace to be called a *reverberatory furnace*. *See* Furnace.

CCXL. DORONICUM. (q)

CCXLI. DRAGON's BLOOD. (r)

CCXLII. DUCTILITY. Ductility is a property poſſeſſed by certain ſolid bodies, which conſiſts in their yielding to percuſſion, preſſure, and in receiving different forms, without breaking.

This property is nothing elſe than a continued adheſion of the integrant parts of thoſe bodies which have this property, although theſe parts change place reſpectively to each other. A body, therefore, cannot be ductile, excepting its integrant parts be ſo diſpoſed, that, while ſome of its contiguous parts are forced to ſeparate, others apply themſelves, ſo that the whole ſhall be ſtill one continued ſubſtance.

(q) Doronicum. From two ounces of the dry root were obtained by water fourteen drams of extract; and from the ſame quantity, with ſpirit, four drams and a half. This root is ſuppoſed by ſome to be poiſonous, eſpecially when freſh. *Neuman*.

(r) Dragon's Blood is a red colored, inodorous, and inſipid reſin, unſoluble in water, ſoluble in ſpirit of wine and in oils, to both which liquors it communicates a red color. By fire it is ſuſible, inflammable, and it emits an acid vapor like that of benzoin. A ſolution of dragon's blood in ſpirit of wine is uſed for ſtaining marble, to which it gives a red tinge, which penetrates more or leſs deeply according to the heat of the marble during application. But as it ſpreads at the ſame time that it ſinks deep; for fine deſigns, the marble ſhould be cold. Mr. Du Fay ſays, that by adding pitch to this ſolution, the color may be rendered deeper.

The figure of the integrant parts of ductile bodies contributes alſo probably to their ductility: but as we have not any certain knowledge of the form of the integrant parts of any body, we cannot explain ductility more preciſely and particularly.

Some bodies are ductile both when they are hot and when they are cold, and in all circumſtances. Such are metals, and particularly gold and ſilver. Other bodies are ductile only when they have a certain degree of heat; ſuch as wax, and ſubſtances of the ſame kind, and glaſs (s). The degrees of heat requiſite to render theſe bodies ductile vary according to their different natures. In general, the heat muſt be ſuch as to be in a middle ſtate betwixt ſolidity and perfect fuſion or fluidity. As wax, for inſtance, is fuſible with a very ſmall heat, it may be rendered ductile by a ſtill ſmaller heat; and glaſs, which requires a moſt violent heat to be perfectly fuſed, cannot acquire its greateſt ductility without being made red-hot and almoſt ready to fuſe. Laſtly, ſome bodies are rendered ductile by the interpoſition of the parts of a fluid. Such are certain earths, and particularly clays. When theſe earths have abſorbed a ſufficient quantity of water to bring them into a middle ſtate betwixt liquidity and ſolidity, that is, to the conſiſtence of a conſiderably firm paſte, they have then acquired their greateſt ductility. Water has preciſely the ſame effect upon them in this reſpect as fire has upon the other bodies mentioned.

CCXLIII. DULCIFICATION. When cauſtic and corroſive bodies are rendered milder by being combined with another ſubſtance, they are ſaid to be *dulcified*. This term is moſt commonly applied to the effect produced upon mineral acids by their union with ſpirit of wine. *See* SPIRITS *of* NITRE, *of* SALT, *and of* VITRIOL (DULCIFIED).

CCXLIV. DYING. The art of dying conſiſts in extracting from various ſubſtances coloring particles, and applying them to ſtuffs or other matters intended to be dyed, ſo that they ſhall adhere as firmly and durably as poſſible. (t)

(s) Laſtly, other bodies, as ſome kinds of iron, namely, thoſe called by workmen *red-ſhort*, braſs, and ſome other metallic allays, are ductile only when cold, and are brittle when hot. Concerning the ductility of metals, *ſee* METALS.

(t) DYING. Notwithſtanding the labors of Meſſrs. Hellot, Aſtruc, Du Fay, Juſſieu, and of ſome other authors, by which many proceſſes for dying are aſcertained; and notwithſtanding the attempts of Mr. Hellot to explain theſe proceſſes, yet the theory of dying is far from being known or eſtabliſhed. We do not ſufficiently underſtand the nature of the colorific particles of dying ſubſtances; nor the action of the ſalts and other matters uſed in moſt of the proceſſes for durable dyes; nor the cauſes of the differences of the ſeveral ſtuffs made of wool, ſilk, cotton, or thread, with regard to their aptitude to receive certain dyes. Many experiments are required to elucidate theſe ſubjects.

Before we mention Mr. Hellot's Theory of Dying, we muſt obſerve, that dyers enumerate five colors which they call primary, from the mixtures of which the other colors are produced. Theſe are blue, red, yellow, nut-color, and black. *Good dyes* are thoſe which can reſiſt the action of water, air, and of certain ſaline and ſaponaceous liquors which are uſed as proofs of the durability of colors. *Falſe dyes* are thoſe which cannot reſiſt theſe proofs. We may eaſily conceive the action of falſe dyes; that a colored decoction ſhould color any ſtuff dipped into it by the adheſion of part of it to the ſtuff; and that when the ſtuff has become dry by the evaporation of the water of the decoction, it may again be deprived by waſhing with water of the coloring ſubſtance; which being

ſoluble,

Although the principles of all the mechanical arts have a ſinglar dependance on chemiſtry, as we have endeavoured to ſhew in many parts of this work, few of them are ſo intimately related to this ſcience as the art of dying, all the operations of which are ſo many chemical operations. Theſe operations muſt be deſcribed at full length to ſhew all their relations to chemiſtry; but theſe de-

ſoluble, as it was originally, in water, may eaſily be waſhed out of the dyed ſtuff: but the action of thoſe dyes which, although once diſſolved or ſuſpended in water, cannot again, after they are applied to ſtuffs, be waſhed out, is not ſo eaſily underſtood. We ſhall here treat only of this latter ſort, or good and durable dyes. Dyes of different colors require different treatment. Stuffs to be dyed of a *red* [illegible] *yellow* color muſt be boiled in water with alum and tartar before they are dipped into the dying decoctions: the red coloring materials are *kermes*, *cochineal*, *gum-lac*, and *madder*; the yellow materials are *luteola*, or *dyers weed*, and other *yellow flowers*. The ſtuffs for *blue* dyes require no previous preparation. Theſe blue dyes are made of *indigo*, or the blue fecula obtained from *woad* (*ſee* INDIGO and WOAD), diſſolved in a lixivium of fixed alkali, or in urine, with or without the addition of ſome green vitriol. The ſtuffs intended to receive a *root color* require no previous preparation but to be ſoaked in warm water. Theſe dyes are chiefly decoctions of *wallnut ſhells*, *wallnut-roots*, *alder-bark*, *ſumach*, and *ſaunders*. To theſe no ſaline or other matter is added. The *black* dyes, which are *inks*, or decoctions of *galls*, mixed with *green vitriol*, require no previous preparation of the ſtuff.

Mr. Hellot's Theory of Dying is, that the coloring particles are fixed into the pores of ſtuffs chiefly by means of a vitriolated tartar, which he believes to exiſt in each proceſs, to be produced by the acid of alum and alkaline baſis of tartar in the proceſs for red and yellow dyes, to exiſt originally in the pot-aſh employed in the blue dye, and in the nuts and roots employed in the root-colored dye. He ſuppoſes that the pores of the ſtuff are cleanſed and enlarged by the preparatory ſalts, and by the boiling water, ſo as to receive the coloring particles, which particles are afterwards detained by the contraction of the pores occaſioned by cold; and further, that theſe pores are lined with a ſaline cruſt of vitriolated tartar, or of tartar; which ſalts being difficultly ſoluble in water, retain firmly the coloring particles. But this theory cannot be admitted, when we conſider, that vitriolated tartar does not exiſt in any of the materials uſed in ſome of the proceſſes for dying, as in the root-color materials, from which no vitriolated tartar can be obtained, unleſs accidentally, till they have been by burning reduced to aſhes, and even then the quantity is exceedingly ſmall; that although common pot-aſh generally contains ſome vitriolated tartar, yet Mr. Hellot has not ſhewn that pure fixed alkali is incapable of producing the ſame effect; and laſtly, that vitriolated tartar and tartar, although they require much water to be diſſolved, are yet ſoluble by water; and therefore if the coloring particles were fixed chiefly by means of theſe ſalts, they might be waſhed out by a large quantity of water; which we find to be contrary to experience.

We ſhall find it more difficult to ſubſtitute a true theory, than to refute that of Mr. Hellot. Many experiments ought to be previouſly made. Nevertheleſs we ſhall obſerve, that the colorific particles uſed in dying ſeem to be unſoluble in water, in ſpirit of wine, and even in alkaline lixiviums; that their diffuſion through theſe liquids is cauſed merely by their adheſion to certain gummy and reſinous particles; and that they may be diſengaged from thoſe gummy and reſinous matters, by applying a piece of ſtuff, to which they have a greater adheſive power, which ſeems to be the caſe of the root-colored and blue dyes; or by applying another ſubſtance, to which they have a greater power of adheſion, ſuch as the earth of alum, in thoſe dyes where that ſalt is uſed together with ſome ſubſtance, as fixed or volatile alkali, capable of decompoſing alum; or as the ferrugineous earth of the green vitriol in black dyes, to which the colorific particles of the galls adhere; which earths are capable of applying themſelves, and of adhering to the ſtuffs. The ſeparation of the coloring particles from the gummy and reſinous matters is probably facilitated by the addition of acid tails would lead us too far from our object. We muſt confine ourſelves to ſhew the moſt general principles of dying. Theſe have been already explained in a preliminary diſcourſe to the *Art of Dying Silk*, which is one of the diſſertations upon the arts publiſhed by the Royal Academy of Sciences. We ſhall here only make an extract of what is ſaid there, to oblige thoſe readers who have not that collection.

Moſt vegetable and many animal ſubſtances contain coloring principles which may be extracted and applied to other bodies: but theſe coloring principles are not always nearly of the ſame nature, and in the ſame ſtate; and theſe differences require that different methods ſhould be employed for the extraction and application of them.

Some of theſe coloring particles reſide partly in a ſaponaceous extractive ſubſtance, and partly in an earthy and reſinous matter. When ſubſtances, the colorific particles of which are in this ſtate, are boiled in water, they impregnate the water with their color; becauſe a part of the reſinous earthy portion is mixed and diffuſed in the water by means of the ſaponaceous extractive prin-

and neutral ſalts, which may coagulate in ſome meaſure the vegetable matters, and leave the colorific particles diſengaged; ſo that they may apply themſelves to the ſtuff, or to the abovementioned earths. Theſe ſalts are alſo uſeful by heightening certain colors; all acid ſalts and alum having the property of heightening the red colors of vegetables. The metallic ſalt uſed in the *ſcarlet* dye (which conſiſts of a decoction of *cochineal*, to which a ſolution of tin in aqua regia, and ſome tartar are added) has alſo the effect of changing the crimſon color of cochineal to a vivid ſcarlet; and probably has alſo the other effects of alum, of affording an earth, namely that of tin, to which the coloring particles may adhere, and of coagulating the vegetable matters, ſo that they ſhall leave the coloring particles detached and ſuſpended in the water. The chief difference then betwixt the falſe and true dyes is, that the coloring particles in the former dyes are applied to ſtuffs, together with ſome gummy or reſinous matter to which they adhere, and are therefore liable to be waſhed out along with theſe matters by any liquid capable of diſſolving gums or reſin; while the coloring particles of the true dyes are applied to ſtuffs, either alone, or adhering to ſome fine earth, as the earth of alum or of tin; and as both the coloring and the earthy particles are unſoluble in any liquids, to which they are moſt apt to be expoſed, as water, ſoap-ſuds, &c. they are capable of reſiſting the action of theſe liquids, and are therefore durable. Some dyes are alſo called *falſe*, becauſe their colors are depraved by expoſure to the ſun and to the air. Theſe effects cannot, I fear, be explained without a further knowledge of colors, and of the action of light and air upon colors, than has hitherto been communicated. We here treat not of the cauſes or changes of colors, but of the application and adheſion of coloring particles. To confirm our conjectures on this ſubject, we may obſerve, that when the coloring particles of vegetables and animals are diffuſed in an alkaline lixivium, by means of gummy, reſinous, or oily matters to which they adhere, they may be ſeparated from theſe adheſive matters by adding alum, the acid of which unites with the alkali of the lixivium; while the coloring particles apply themſelves to the baſis or earth of the alum, now diſengaged, with which they form what are called by painters *lakes*, the coloring matter of which is not now ſoluble in water or in ſpirit of wine; although theſe liquids are capable of extracting that coloring matter from the vegetable and animal ſubſtances which contain it, by the intervention, as we ſuppoſe, of ſome gummy or reſinous matters.

For further particulars concerning dying, and the chemical hiſtory of dying ſubſtances, *ſee* BLACK, BLUE, CRIMSON, &c. and COCHINEAL, INDIGO, FLOWERS, FRUIT, LEAVES, &c. The *details* of the particular proceſſes in this art are deſcribed fully by *Mr. Hellot*, in his Treatiſes on the *Art of Dying*.

ciple. If a ſtuff be plunged in a decoction of ſuch ſubſtances, the coloring particles are thereby made to touch and apply themſelves to it, and even to adhere firmly; becauſe the reſinous earthy coloring principle, when once united to the ſtuff, and ſeparated from the extractive principle, is no longer ſoluble either by water, ſoap, ſalts, or other active matters. Several ſubſtances are known, the coloring principles of which are in this ſtate. Of theſe the chief are the *green ſhells of wallnuts*, the *root* of the *wallnut-tree*, *ſumach*, *ſaunders*, *bark of alder*, and the ſhell-fiſh called *murex*, ſuppoſed to be the purple dye of the ancients. Excepting this latter ſubſtance, which gives a fine red, all the reſt give a dun color, called a *root-color*, but which is valuable notwithſtanding its little luſtre; becauſe it is very uſeful as a ground upon which other brighter colors may be applied. From the nature of theſe coloring ingredients we may perceive that no preparation is neceſſary for the colors, or for the matters to be dyed. They furniſh the ſimpleſt and moſt practicable kind of dying; for all the operation conſiſts in boiling the dying materials in water, and in dipping the ſtuff to be dyed in this decoction.

The coloring principle of another kind of ſubſtance is contained in a matter altogether reſinous, which is ſo diſpoſed that it cannot be rendered miſcible with water by means of the ſaponaceous extractive principle of the ſame ſubſtance. The principal ingredients of this kind are *indigo*, which furniſhes the blue dye, and the flowers of *cartamus*, or *baſtard Saffron*, from which a very beautiful red is procured. Pure water cannot extract the colors from theſe matters. The blue reſinous part of indigo is alſo of the nature of thoſe which ſpirit of wine cannot diſſolve: but as fixed alkaline ſalts are capable of acting upon all reſinous matters, they are uſed ſucceſsfully to extract the coloring parts of theſe ingredients, and to render them fit for dying.

The coloring principles of almoſt all the other vegetable and animal matters which furniſh colors for dying, and which are very numerous, are of a purely extractive ſaponaceous nature, and may conſequently be eaſily extracted by water alone; but as they are ſoluble in water, they might eaſily be waſhed away from the ſtuffs to which they have been applied, if theſe ſtuffs had not previouſly been impregnated with ſome matter capable of producing ſome change or decompoſition on the coloring part.

A method has been found of fixing colors upon ſtuffs by different ſalts, with which the ſtuffs are impregnated before they are dyed. The extractive coloring particles are ſo changed by theſe ſalts, that they loſe their property of being ſoluble in water, and are even rendered capable of reſiſting the action of ſoap, and other ſubſtances which are apt to deſtroy moſt colors, and are therefore uſed to prove the durability of theſe.

Of all the ſalts which may be employed for this purpoſe, *alum* is found to be the fitteſt: it is therefore generally employed for all extractive tinctures, which are very numerous, the principal of which are *luteola*, or *dyer's-weed*, and all the herbs which give a yellow color, *madder*, *vegetable kermes*, *cochenil*, *Braſil-wood*, *log-wood*, and other woods and roots uſed in dying. Alum is not the only ſalt which has this effect. All neutral ſalts with metallic baſes are alſo capable of fixing the extractive colors: but ſome of theſe are very dear, and others change and ſpoil the colors; ſo that alum is ſolely employed for this purpoſe.

All theſe dyes cannot be equally well fixed by alum, or by the other ſalts above-mentioned. Some of them are only ſo much fixed by alum as to reſiſt the action of water, but not of the other ſubſtances uſed to prove the fixity of colors, nor even of the air, during a long time. This latter kind of dyes are called *falſe* or *ſmall tints*, to diſtinguiſh them from the more fixed dyes, called *great* or *good tints*.

Theſe differences muſt proceed from the particular nature of each of the coloring materials: but very accurate analyſes of theſe materials, and a great number of new reſearches muſt be made, before this obſcure ſubject can be explained. It will even appear ſtill more obſcure, when we conſider that the different nature of the ſubſtances to which the dye is applied, ſurprizingly affects the beauty and fixity of colors. For inſtance, the red color of madder, which is ſufficiently beautiful and fixed upon wool and cotton, gives but a falſe tint upon thread; alſo cochenil, which gives a vivid and bright flame-colored red to wool, and even to moſt animal matters, does not adhere to ſilk, cotton, or thread. In the particular details of the proceſſes for dying the different kinds of matters many other ſingular differences may be found, which require particular attentions to be explained. The moſt general inference from theſe particular details is, that wool and all animal matters are the moſt eaſily dyed; next to them, ſilk and other ſubſtances, which ſeem to be intermediate betwixt the animal and the vegetable nature; and laſt of all, thread, and vegetable matters.

The few facts and general principles we have advanced on the art of dying are ſufficient to ſhew its connexion with chemiſtry, and how much it may be improved by this ſcience.

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CCXLV. EARTHS. Earth is one of the four ſimple ſubſtances called elements, or primitive principles; becauſe they are indeed the moſt ſimple of all thoſe which enter into the combination of compound bodies. We cannot doubt, in particular, that the greateſt part of the compounds which we can analyſe contain earth as one of their principles; for after art has exhauſted all its efforts to decompoſe them, a fixed and ſolid matter always remains, upon which no change can be produced; and this is what is generally called earth. It has the ſolidity, weight, fixity, and other principal properties of the maſs of ſolid matter which forms the globe we inhabit, called alſo *the earth.*

Theſe general conſiderations are ſufficient to convince us, that in nature a ſubſtance exiſts whoſe properties are different from thoſe of fire, air, water; and which is, like theſe other ſubſtances, one of the elements of compound bodies. But a vague aſſertion like this does not ſatisfy chemiſts. Beſides the aſcertaining of the exiſtence of the different ſubſtances ſubmitted to their examination, they require to know the properties of theſe ſubſtances in their greateſt degree of purity and ſimplicity: but they have found much difficulty and uncertainty in inveſtigating the eſſential properties of the pureſt and ſimpleſt terreſtrial element.

Earth is not found ſo pure as the other elements, fire, air, and water, which, though not entirely free from mixture, are however ſo pure, that we may certainly and eaſily diſcover their fundamental properties. Theſe properties of each of theſe pure elements are ſo well aſcertained, and ſo evident, that nobody has yet attempted to diſtinguiſh different kinds of fire, air, or water, notwithſtanding the differences which may ariſe from the heterogeneous ſubſtances with which they are almoſt always mixed.

But we cannot ſay the ſame of earth; for a conſiderable number of ſubſtances are called earths, becauſe they poſſeſs the principal properties of the terreſtrial element: but theſe ſubſtances, when examined more particularly, are always found to differ from each other ſo much in other reſpects, and to be ſo difficultly purifiable from heterogeneous matter, that we have not aſcertained whether only one ſimple and elementary earth, or ſeveral ones eſſentially different, although equally ſimple, exiſt.

The moſt general and moſt probable opinion is, that as only one kind of fire, of air, and of water, ſo only one kind of ſimple elementary earth, exiſts. Alchemiſts chiefly have endeavoured to diſcover this primary earth, not with an intention to aſcertain its properties, but becauſe they imagined that as gold is the pureſt of metals, the earth of which it is partly compoſed muſt be alſo the moſt pure; they have, therefore, ſearched every where for this earth, which they call *pure earth* and *virgin earth*. They have endeavored to obtain it from dew, rain, the air, aſhes of vegetables, animals, and ſeveral minerals: but it was impoſſible to find it in compound bodies; for we ſhall ſee that when once this element makes part of a compound body, it cannot be diſengaged from the ſubſtances with which it has united.

Some of the beſt philoſophical chemiſts have rather choſe to admit different kinds of elementary earths, than to inveſtigate the nature of the moſt ſimple and elementary of all. Becker admits three principles, which he calls *earths*, namely, *the vitrifiable*, *the inflammable*, and *the mercurial earth*, which are known by the name of *the three earths of Becker*.

Mr. Pott, examining the principal natural earths, divides them into four kinds, *the vitrifiable*, *the calcareous*, *the argillaceous*, and *the gypſeous earths*. This able chemiſt ſhews the eſſential properties of theſe four kinds of earths, without affirming that they are all equally ſimple, and without even determining which of them he conſiders as moſt ſimple.

As earth is an element which enters into the compoſition of almoſt all bodies, and which ſeems chiefly to affect their properties, it deſerves an accurate inveſtigation to diſcover which is the moſt ſimple and elementary of all the ſubſtances to which the name *earth* has been applied. This ſubject ſeems capable of deciſion by conſidering, firſt, what are the eſſential properties by which earthy ſubſtances differ from other elements, and then by determining that earth to be the moſt pure and ſimple, which poſſeſſes theſe properties moſt eminently and deciſively; for we cannot doubt, that the properties diſtinguiſhing earthy matters from the other elements are the eſſential and ſpecific characters of the earthy element; and alſo, that the more eminently any ſubſtance poſſeſſes theſe characteriſtic properties of the earthy element, the nearer it approaches to this element, conſidered in its ſtate of purity and ſimplicity.

This being eſtabliſhed, if we compare with the other elements all the ſubſtances which may reaſonably be conſidered as earthy, we ſhall ſoon be convinced, that theſe poſſeſs much greater *weight*, *hardneſs*, *fixity*, and *infuſibility*, than any other element; for theſe qualities are inſenſible, or do not exiſt, in the element of fire; they are in an exceedingly ſmall degree in the air, and are more ſenſible and conſiderable in water; but are infinitely leſs than in any thing which can be conſidered as earth. Hence we ought to conclude, that the qualities above-mentioned are the diſtinguiſhing and characteriſtic eſſential properties of the earthy element. But theſe qualities are not ſo eminently united in any of thoſe ſubſtances which are conſidered as earthy, as in that which is called by chemiſts, *vitrifiable earth*. We ſay then, that this earth is the heavieſt, hardeſt, moſt fixed, and moſt infuſible, and even the moſt *apyrous* of all earths, when it is very pure; and alſo that it is the moſt homogeneous, the moſt ſimple, and elementary earth, as we ſhall prove by a more particular examination of its properties, and by a compariſon of theſe with the properties of the other earthy ſubſtances.

We call that *vitrifiable earth*, the integrant parts of which when united form maſſes of matter or ſtones, abſolutely white and colorleſs, much more tranſparent and hard than any other natural ſubſtances, and which ſuffers no alteration, or even fuſion, by the ſtrongeſt fire which we can apply to it.

Amongſt the hard ſtones called vitrifiable, we indeed know few which ſtrictly poſſeſs all the qualities we have mentioned; becauſe in very few of them the vitrifiable earth is pure. Moſt of theſe ſtones, as hard pebbles of all kinds, ſand, free-ſtone, agates, quartz, rock-cryſtal, and the ſtones called precious, are deficient in ſome of the qualities required to conſtitute the pureſt vitrifiable earth. Some of them are opake, or only ſemitranſparent; others are colored; ſome are fuſible by a great heat; and, laſtly, others, although much harder than any other kind of ſtones, want the laſt degree of hardneſs; all which prove that they are mixed with heterogeneous ſubſtances, chiefly phlogiſtic, metallic, or even earthy, of a different kind.

The pureſt of all the vitrifiable ſtones is the diamond, which is perfectly white, free from all color or ſtain, and tranſparent. This ſtone is alſo known to be the hardeſt of all, is abſolutely apyrous, that is, incapable of receiving any alteration by the moſt violent heat. We, therefore, conſider the matter of this ſtone as the pureſt, ſimpleſt, and moſt elementary earth that is known. The properties, then, of this ſtone, and of the other vitrifiable ſtones which reſemble it, may give us notions of the properties of primary, elementary, uncharged earth. In this our opinion is conformable to that of the illuſtrious Stahl, who indeed admits the three earths of Becker; but, at the ſame time, corrects the theory of this chemiſt, by declaring that he only conſiders the firſt earth of Becker, or vitrifiable earth, as the proper terreſtrial or earthy element. *Specimen Beckerianum*, p. 44. No. 25.

But before we particularly enumerate the properties of this earth, we ought to make ſome obſervations on thoſe hard, earthy, and ſtoney matters called by chemiſts *vitrifiable*.

Our firſt obſervation ſhall be concerning the name *vitrifiable earth*; becauſe it may produce falſe notions of the nature of theſe ſtones.

We ſay then, that the epithet, *vitrifiable*, is given, firſt, becauſe ſome ſtones of this kind are, by means of their heterogeneous matters, capable of fuſion and converſion into glaſs, without addition, and merely by the action of a very violent heat; and ſecondly, becauſe other ſtones of this kind, which are leſs fuſible than theſe now mentioned, but which are yet more ſo than ſtones of other kinds, require for their perfect fuſion and vitrification a leſs quantity of flux, and a leſs degree of heat.

In the ſecond place, as all the earths and ſtones called vitrifiable have, notwithſtanding their impurity, more hardneſs and tranſparency than others, and are fitter to communicate theſe good qualities to glaſs, they are employed preferably to any other earths in the compoſition of glaſs, or artificial cryſtal. Theſe are the only reaſons why this kind of earth has been called vitrifiable. But we ought not from thence to conclude, that the earthy ſubſtance which almoſt entirely compoſes them is more fuſible and more vitrifiable than other earths: on the contrary, I again ſay, that vitrifiable earth, when very pure, is of all earths the leaſt fuſible, and the leaſt vitrifiable. I was preſent at a fine experiment made relatively to this ſubject. Some diamond powder was mixed with a ſufficient quantity of fixed alkali to vitrify any other earthy matter, and the mixture expoſed to a heat ſufficient for the moſt difficult vitrifications. After the operation, no glaſs was found in the crucible; but part of the alkali had been diſſipated by the violence of the heat, and the diamond powder did not ſhew any ſigns of a beginning fuſion. Thus we may conſider it as an eſtabliſhed truth, that the earths and ſtones called vitrifiable are not eſſentially and really ſo; that the fuſibility of ſome of theſe, by which property they are rendered the fitteſt earths for vitrification, proceeds from heterogeneous matter with which they are mixed; and that, in general, the whiteſt, cleareſt, moſt tranſparent and hardeſt of theſe ſtones are alſo the moſt refractory and unfuſible. *See* VITRIFICATION.

Our ſecond obſervation ſhall relate to the weight of vitrifiable earths. We have already ſaid, that the pureſt and ſimpleſt of all earths ought to be alſo the heavieſt; and accordingly we find that pure vitrifiable earth is ſpecifically heavier than calcareous, argillaceous, gypſeous, or other earths. We are, nevertheleſs, no leſs certain, that metals, metallic earths, and ſeveral kinds of ſpars, both calcareous and ſelenitic, are much heavier than the moſt compact vitrifiable ſtones: but we muſt conſider that theſe earthy matters are very compound bodies in compariſon of the purer earths. An objection may be made, that if elementary earth be eſſentially the heavieſt of all matters, then any body compounded of this earth and other matters ought to be lighter than pure earth. This objection would be unanſwerable, if the ſpecific gravity of a body was always equal to the ſpecific gravities of the integrant and conſtituent parts which compoſe it: but as theſe parts may be ſo arranged that void ſpaces may be left betwixt them, ſometimes larger, and ſometimes leſs, therefore a body compoſed of parts eſſentially lighter, may yet have a greater ſpecific gravity than another body whoſe parts are eſſentially heavier; and this happens in all metals and metallic matters. *See* METALS and METALLISATION. Thus the gravity of metals and of metallic earths and ſtones ought not to prevent our conſidering the pure and elementary earthy principle as the heavieſt of all natural ſubſtances.

After theſe explanations, we may conſider the properties of elementary earth in the pureſt vitrifiable ſtones, and may compare them with the properties of the other elements. Since of theſe elements water is the moſt capable of our examination, we ſhall compare it with the pureſt vitrifiable earth; obſerving always, that we conſider theſe elements in their ſtate of aggregation; for we have no method by which their primary integrant parts can be known and conſidered ſeparately.

If then, on one ſide, we conſider a maſs of water, abſolutely pure, expoſed to a cold ſufficient to form it into hard, compact, ſolid ice; and if, on the other ſide, we compare to this a maſs of vitrifiable earth, as a diamond, or even a very fine and clear rock-cryſtal, we ſhall eaſily perceive that theſe two matters reſemble perfectly each other in their appearance; we ſhall find that both of them are colorleſs, inodorous, and taſteleſs; and that their tranſparency is alike: therefore, if we could no further examine their properties, we muſt conſider them as being of the ſame matter: but when the other properties of theſe ſubſtances are examined, as weight, hardneſs, fuſibility, and fixity, then we ſhall perceive differences, which indeed are only in the degrees of theſe properties poſſeſſed by each of the two ſubſtances: but the difference of theſe degrees is very great. Thus the ſpecific gravity of rock-cryſtal is almoſt four times that of ice: their hardneſs alſo is ſo different, that the earthy ſubſtance reſiſts the point of the hardeſt ſteel, without being ſcratched; and when ſtruck by ſteel, elicits ignited ſparks; while ice may be eaſily cut by inſtruments of ſteel, and does not elicit ſparks when ſtruck: their difference of fuſibility is ſtill more ſenſible, the ice becoming fluid by a gentle warmth, which does not ſenſibly affect rock-cryſtal in any reſpect. I ſay, *ſenſibly*; becauſe with the leaſt diminution of cold it is certainly ſomewhat affected, ſo far as to be expanded, and conſequently to be leſs hard and heavy. But theſe two latter affections, particularly, are ſo inconſiderable in a vitrifiable ſtone with the heat neceſſary to thaw ice, that probably it cannot be eſtimated. Laſtly, if we continue to examine theſe two ſubſtances by a heat gradually augmented, we ſhall ſee the water totally diſſipated in vapors, before even either of theſe ſubſtances has become red-hot, and the vitrifiable ſtone ſupport a heat almoſt infinitely encreaſed, till it is white and dazzling, without becoming fluid, or without any part of it exhaling in vapors; for it may be afterwards found to have loſt no weight by having been expoſed to this heat.

So far we can extend our examination; for I do not believe that a pure vitrifiable earth, as a diamond, can be fuſed even in the focus of the beſt burning ſpeculums: but ſuppoſing that a ſufficient heat might be produced to procure this fuſion, or that this ſtone were expoſed to infinitely greater heat, ſuch as we conceive to be in the body of the ſun, it would then melt, and would even be reduced to vapors, if the heat were ſufficiently violent; and when this heat ſhould ceaſe, it would, when it cooled, fix again, and become ſuch a ſubſtance as it was before. The ſame would happen to vitrifiable earth in theſe circumſtances, which does happen to water rendered fluid, and reduced to vapor by a certain heat, and which is again frozen into ſolid ice when that heat is removed. The differences, therefore, betwixt theſe two ſubſtances are only, as we have already ſaid, in the degrees; but alſo theſe differences are very conſiderable.

From theſe conſiderations an inference ſeems deducible, that the elements or the ſimpleſt ſubſtances which we know are eſſentially only one and the ſame matter, and only differ from each other in the quantityand in the form of their primary integrant molecules, which, from this difference of form and quantity, have a greater or leſs tendency to unite together; and we might be inclined to believe that a certain kind of analogy or gradation exiſts betwixt them: thus, for example, that earth ſhould be to water, what water is to air, and what air is to fire, or rather to ſome unknown intermediate ſubſtance betwixt air and fire; for the difference betwixt theſe two latter elements appears too great to be compared with the differences amongſt the three former. But theſe are ſpeculations entirely ſyſtematic; for we are very far from being capable of eſtimating the eſſential properties of elements ſufficiently exactly, to be able to determine any thing preciſely and poſitively in this reſpect.

However that may be, we cannot doubt but that earth chiefly differs from the other elements by the powerful tendency which its parts have to each other, and by the force of their coheſion. For its hardneſs, fuſibility, fixity, and even its gravity, are evidently the neceſſary conſequences of this principal and eſſential property. And by this property does the earthy element act in the ſyſtem of nature. By this it is the cauſe of the conſiſtence of all ſolid bodies.

It receives, fixes, and incorporates in ſome meaſure the other elements.

Laſtly, as without fire the whole world would be one maſs of ſolid and immoveable matter, ſo without earth it would be a confuſed heap of fogs, vapours, a chaos of incoherent atoms, deſtitute of that harmony and equilibrium which ſuſtain it.

We have already had occaſion to ſhew in ſeveral parts of this work, that the general tendency of the parts of matter to each other is the grand ſpring of the univerſe; that by this power, all combinations, ſolutions, and, in a word, all the movements and operations of nature are performed: and as we have ſhewn that the earthy element poſſeſſes this tendency in the greateſt degree, we ought to conſider earth as being in this ſenſe the moſt active and powerful of all elements. This notion is contrary to the opinions of chemiſts and philoſophers, who from not having ſufficiently examined this ſubject, and being deceived by the ſeeming inactivity of earth conſidered in its ſtate of aggregation, have affirmed it to be an element purely paſſive, and only capable of impulſe from other elements. Indeed when the parts of earth are united together, they appear to be, and really are, incapable of acting upon other bodies, becauſe they then exhauſt all their action mutually upon each other. But the force with which they adhere together, and which renders them incapable of forming other unions, the extreme hardneſs and inſolubility of a maſs of pure earth, ought to demonſtrate to a true philoſopher, that if we ſuppoſe the parts of earth ſo ſeparated from each other, that they cannot unite, and exhauſt their action upon each other, they muſt then poſſeſs all their force of tendency, which muſt be very great, they muſt be in a ſtate of violent effort, and conſequently muſt tend with extreme force to unite with any parts of matter which may be within their reach, and to which they can apply themſelves. We do not indeed know any pure earth which is in this ſtate of broken aggregation: but we know compounds in which the primitive integrant parts of the earthy element are only combined with the parts of water, which are incapable of ſatisfying all their tendency to union. Theſe are the moſt ſimple ſaline ſubſtances, ſuch as acids and alkalis; and we may judge by the force and vehemence of the action of theſe ſolvents, how violent the action of the parts of earth would be, which ſhould be capable of exerting all the attractive force which belongs to them.

Although the entire maſs of our globe be probably formed by an immenſe heap of elementary, vitrifiable, and even actually vitrified earth, as the illuſtrious Buffon believes, we do not find upon its ſurface but a very ſmall quantity of this earth, unaltered, and in its primary ſtate. Perhaps even none of it exiſts in that ſtate: for, as we have obſerved, the common vitrifiable ſtones, which are chiefly formed of it, are very far from the degree of purity of primitive elementary earth; and even perfect diamonds, which ſeem of all theſe ſtones to approach the neareſt to this purity, ſeem to have been elaborated by the waters, if we can judge from their regularly cryſtallized form.

We ſhall not be ſurprized at the ſcarcity of pure earthy element, if we conſider that the ſurface of the earth, which alone we are acquainted with, has been from the beginning of the world expoſed to the conſtant action of the other elements; and that by uninterrupted operations, nature, aſſiſted by fire, air, and water, has gradually diſunited the integrant parts of elementary earth, and by combining them in manners and proportions infinitely various with parts of the other elements, has formed the numberleſs compound bodies, which occupy a certain thickneſs near the circumference of the globe, probably very ſmall in compariſon of the diameter of the earth, but very large with regard to us, whoſe greateſt efforts only extend to a few hundred feet below its ſurface.

All the portions of elementary earth, which, having been thus diſunited, have afterwards been combined with parts of matter of other kinds, have received very ſenſible changes, the effects of which always remain, and prevent them from appearing afterwards, notwithſtanding future decompoſitions, in their original purity and ſimplicity. They then aſſume different forms according to the nature of the compounds into the combination of which they have entered. Thus, for example, the earth which makes parts of cruſtaceous animals, or rather of their ſhells and ſcales, takes the character of that earth which is called *calcareous*, and which is capable of converſion into quicklime by the action of fire. The earth which has entered into the compoſition of plants, and even of the bodies of animals, after having been deprived as much as is poſſible of the principles of theſe compounds to which it was united, forms all the *argillaceous earths*. Some of theſe are found which partake both of the calcareous and of the argillaceous properties, and are called *marles*. Marles have not yet been ſufficiently well examined by chemiſts. They are either a mixture of clay and calcareous earth, or they have been ſo elaborated by nature as to be transformed into a particular earth, partly calcareous, and partly argillaceous, ſuch as the earth of animal bones ſeems to be.

As the earth which forms ſands and the common impure vitrifiable ſtones retains more than the reſt the eſſential properties of elementary earth, notwithſtanding the heterogeneous, phlogiſtic, and other parts with which it is mixed; we cannot eaſily know whether it has once made a part of ſome very compound bodies, from the principles of which it has been more perfectly ſeparated than the argillaceous and calcareous earths; or whether it be the primitive earth, which, without having made part of any intimate combination, has only been divided and conveyed by waters, and the parts of which have afterwards reunited, having only contracted a ſlight union with ſome phlogiſtic, metallic, and other matters, with which it is found mixed. This latter ſuppoſition appears to me to be the moſt probable. But very extenſive reſearches in natural hiſtory and in chemiſtry are requiſite to determine this queſtion.

From what we have ſaid concerning the principal kinds of earths which form the ſurface of the globe, we may conclude, that excepting the pureſt vitrifiable earth, all the others are mixed with heterogeneous matter. By theſe remaining heterogeneous matters are the different kinds of earth ſpecified and characteriſed: and as they all preſerve and retain their peculiar character, we ought to conclude from thence that theſe extraneous matters are very intimately united. To purify and ſimplify theſe mixed earths, ſo that they ſhall be aſſimilated to the pureſt vitrifiable earth, would be a fine problem. But, probably this problem is beyond the power of our art. For as in general the perfect ſeparation of two ſubſtances, united together, is exceedingly difficult, this difficulty muſt greatly increaſe, when one of the two ſubſtances to be ſeparated has a very ſtrong attractive power, as earth has. This is the true reaſon why we find ſo ſmall a portion of pure earth amongſt the bodies within our reach; and that on the contrary, the globe is covered with ſo great a quantity of earthy ſubſtances differing from each other ſo much, that we might be inclined to believe them to be bodies eſſentially different. *See the articles*, EARTH (CALCAREOUS), EARTH (VITRIFIABLE). (*u*)

CCXLVI. EARTH (ANIMAL). (*x*)

(*u*) In this article the author has advanced ſome ingenious ſpeculations, but in my opinion ſeveral of his propoſitions are affirmed without proof, and ſome of his inferences are not concluſive. The ſubject does not appear to me capable of being treated ſo deciſively. Moſt philoſophers, ancient and modern, have enumerated, according to their theories, the *elements* of which they believed all ſubſtances to be conſtituted. Nevertheleſs, they have not yet proved the exiſtence of any one element. The impoſſibility even of ſuch a proof appears from conſidering, that the only reaſon which can induce us to believe that any ſubſtance is an element is, that we are incapable of decompoſing that ſubſtance; and that our incapacity to decompoſe does not neceſſarily imply an impoſſibility of decompoſition. The improbability of the conjecture that fire, air, water, earth, are the only elements, might eaſily be ſhewn. If we mean by element whatever ſubſtance we are incapable of decompoſing, (and this is the only preciſe meaning which can be formed of it) then many other ſubſtances are entitled to be enumerated amongſt elements.* According to this meaning the number of elements will decreaſe, when means of decompoſing ſome of thoſe which cannot now be decompoſed are diſcovered. The author believes that only one kind of elementary earth exiſts, and he further believes that this earth is that which he and ſome other authors call *vitrifiable*. But beſides that the claſs of earths called vitrifiable contains many ſubſtances, the properties of which are exceedingly different, no proof can be given that *thoſe* ſubſtances which are believed to be the pureſt of this claſs of earths, as diamonds, are more ſimple and elementary than calcined calcareous earths, argillaceous earths, earth of magneſia, metallic or many other earths; all which, when purified by ordinary methods, are as incapable of decompoſition as diamonds are, and conſequently as well entitled to be conſidered as elementary.

Earths are divided by Mr. Pott into vitrifiable, argillaceous, calcareous, and gypſeous. The author of the Dictionary follows this diviſion. Other authors have invented other diviſions, and enlarge the number of claſſes, by which their diſpoſitions are more comprehenſive and diſtinct.

But although theſe arbitrary arrangements of natural ſubſtances may aſſiſt learners, yet as they are all very imperfect, our knowledge will be alſo very imperfect, unleſs we conſider ſeparately each ſpecies. In the notes to this Dictionary, therefore, the chemical properties of each ſpecies, as well as of the genera and claſſes of earths, (in which are comprehended, not only ſubſtances, commonly called earths, but alſo ſtones, ſlates, ſpars, and talks) ſhall be mentioned as the names of theſe ſpecies occur in the alphabetical order.

(*x*) EARTH (ANIMAL) is the earth of ſhells of animals, or that which is obtained by calcination or putrefaction of animal ſubſtances. 1. The *earths of the ſhells of Sea Fiſhes* have the general properties of calcareous earths. *See* EARTHS (CALCAREOUS). It differs from the mineral calcareous earths in being difficultly ſoluble by vitriolic acid, and in being leſs diſpoſed to vitrify along with ſalts and metallic glaſſes. The *ſhells of eggs* are alſo calcareous, but are ſomewhat fuſible by fire. 2. The *earths of calcined bones and horns* are ſoluble by nitrous, marine, and vegetable acids, and with difficulty by vitriolic acid; but are not calcareous. They are ſaid to be unfuſible, even when mixed with ſalt, metallic glaſſes, and other fuſible mixtures. They are therefore uſed in the compoſition of enamels and opake white glaſſes.

CCXLVII. EARTH (ARGILLACEOUS). *See* CLAY.

CCXLVIII. EARTH (CALCAREOUS). Chemiſts have given this name in general to all earths and ſtones, which being burnt acquire the properties of quicklime.

Nature preſents to us a conſiderable quantity of calcareous earths and ſtones, which have peculiar differences depending on their greater or leſs purity, but which reſemble each other by eſſential properties common to all, and particularly by their capacity to receive calcination.

The principal kinds of theſe earths or ſtones are, chalks, all the calcinable ſhell-ſtones employed for building, all marbles, calcinable ſtalactites, the alabaſters and ſpars which are convertible into quicklime by fire.

Amongſt theſe ſtones a great number are evidently impure and mixed, particularly thoſe which are colored. But amongſt the whiteſt, we cannot eaſily aſcertain which of them contains the pureſt earth, becauſe they have not been chemically compared with this view. We ought certainly to conſider thoſe as the pureſt which poſſeſs in the higheſt degree the eſſential properties of calcareous earth.

All calcareous ſtones are leſs hard than vitrifiable ſtones; none of them ſtrike fire with ſteel, and they all may be eaſily cut with ſteel inſtruments; ſome of them may be found, whoſe parts having been divided, conveyed by waters, and afterwards depoſited ſucceſſively upon each other, form concretions, or rather cryſtallizations, very neat and even tranſparent. Their tranſparency however is always leſs than that of the purer vitrifiable ſtones.

The ſpecific gravity of the different kinds of calcareous ſtones has not been compared with the ſpecific gravity of the vitrifiable. We only know that ſome calcareous ſpars are much heavier than the precious ſtones, and are therefore called *heavy ſpars.* But as we are very certain that the weight of theſe bodies is cauſed by extraneous and not calcareous matter, this does not prevent our eſtabliſhing a general rule that calcareous earth is leſs heavy than vitrifiable; for, excepting the inſtance now mentioned, they all are ſo.

If any calcareous earth or ſtone be divided by trituration and moiſtened with water, it abſorbs a certain quantity of it, particularly if it be very dry; and it forms a kind of paſte, the parts of which have a certain adheſion together. But this paſte is not ſo ductile as that formed by clay and water. It alſo dries and diſunites much more quickly.

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glaſſes. Nevertheleſs, Wallerius affirms, that the earth of calcined bones, by intenſe heat, was changed, without addition, to a green glaſs. *See Mem. Sued.* 1760. The ſame author ſays, that the earth of the whites and yolks of eggs was eaſily fuſible, and that in general the fuſibility of animal earths is in proportion to the ſoftneſs of the parts from which they were obtained. 3. The *earth of blood, fleſh, and ſkins* of animals, is ſoluble by all acids, and is fuſible by fire; that of blood and of other animal fluids being moſt fuſible. This earth, like that of burnt bones and horns, is not calcareous; but both theſe kinds of earth are ſaid to be rendered calcareous by being diſſolved in acids, precipitated by fixed alkali from thoſe acids, and afterwards calcined. They probably contain ſome oleaginous ſubſtance, from which they cannot be entirely diveſted by fire without a previous ſolution in acids.

All acids are evidently capable of acting upon calcareous earth; they attack and diſſolve it with more or leſs effervеſcence. This action of acids upon calcareous earths and ſtones furniſhes us with an eaſy method of diſtinguiſhing them from other earth and ſtony matters, which they reſemble externally.

Calcareous earth ſaturates all acids, and forms with them different *neutral ſalts with baſes of calcareous earth*, according to the kind of acid.

With vitriolic acid, it forms a cryſtallizable ſalt, not very ſoluble in water, called *Selenites.*

With nitrous and marine acids, it forms acrid, bitter, and very deliqueſcent ſalts. They are called *nitre*, and *marine ſalts with calcareous baſes.*

With the acid of vinegar, calcareous earth forms a ſalt not deliqueſcent, and ſuſceptible of a ſilky and ramoſe cryſtallization like a kind of vegetation. This is *acetous ſalt with calcareous baſis.*

Laſtly, with acid of tartar, this earth forms a neutral cryſtallizable ſalt, a *ſoluble tartar with calcareous baſis.* This ſalt is much more ſoluble in water than pure acid of tartar.

Calcareous earth has alſo the property of decompoſing all ammoniacal ſalts, from which it diſengages the volatile alkali, and unites with their acids, when aſſiſted by a certain heat.

Calcareous earths and ſtones, being expoſed to the action of fire, loſe part of their weight, and much of their conſiſtence, which proceeds from the fire carrying off a conſiderable quantity of water which enters into their combination; and as the laſt portions of water are powerfully retained by earth, a very ſtrong heat is requiſite to diſſipate them; and in this principally conſiſts the change produced upon calcareous ſtones when reduced into quicklime. *See* QUICKLIME.

The moſt violent fire we can make is incapable of melting and vitrifying calcareous earths and ſtones, when they are very pure (*y*); but a very remarkable thing is, that theſe ſubſtances, ſo refractory when alone, become true fluxes, and facilitate the fuſion and vitrification of ſeveral other ſubſtances, as ſands and clays. This phenomenon, the cauſe of which is hidden, and not eaſily to be diſcovered, ſeems to depend on a particular diſpoſition of the inflammable principle from which none of theſe matters is entirely exempt, and perhaps on ſome remaining portion of watery principle, ſo ſtrongly retained by calcareous earth, that fire cannot entirely extricate it. *See* VITRIFICATION.

The other characteriſtic properties of calcareous earth are the ſame as the properties of this earth when converted into quicklime, which we ſhall relate and explain under the article QUICKLIME. We ſhall only here obſerve, that if we add to theſe the properties of calcareous earth before calcination, we ſhall evidently ſee that all theſe properties, and the phenomena ariſing from them, depend on the intimate union of a certain quantity of watery principle with the earthy principle in calcareous earth; an union which produces an incipient ſaline combination, according to Stahl's theory, and a ſtrong diſpoſition in cal-

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(*y*) Mr. D'Arcet found that chalk, limeſtone, and one calcareous ſpar, reſiſted a violent, long continued heat; but that other ſpars, ſtalactites, and other calcareous ſubſtances, ſhewed a beginning fuſion. *See Mem. l'Acad. des Sc. ſur l'Action d'un feu violent, égal, & continué,* 1766.

careous earth to paſs into a more compleat ſaline ſtate by a more perfect combination with water. We may hence eaſily perceive, that as calcareous ſtones in their natural ſtate do not differ from vitrifiable ſtones but in being leſs hard, leſs heavy, and leſs fixed, which are preciſely the eſſential qualities by which pure water differs from pure earth; that as, beſides the action of fire deprives calcareous ſtones of much water, calcareous earth chiefly differs from vitriſiable earth by its union with water; and laſtly, that as we cannot doubt but that all calcareous earth has been once one of the principles of organiſed animal bodies, we cannot alſo doubt, but that the water, the portion of phlogiſton (z), perhaps alſo ſome remaining ſmall part of ſaline matter, which are found in theſe earths, and which diſtinguiſh their different kinds, are the remains of the principles with which the elementary earth was found combined in theſe compounds, and which continue firmly united with them. (a)

CCXLIX. EARTH (GYPSEOUS). This name is applied by ſome chemiſts to gypſum, and to the earth contained in ſelenites. As the earth of gypſum, when ſeparated from the vitriolic acid, does not appear to be different from pure calcareous earth, we refer to the articles GYPSUM, SELENITES, *and* EARTH (CALCAREOUS).

(z) Moſt, perhaps all calcareous earths contain ſuch a portion of phlogiſton, as to enable them, by means of heat, to reduce metallic calxes, eſpecially thoſe of lead and biſmuth, which are eaſily reducible, and even in ſome meaſure thoſe of copper and iron. By means alſo of this phlogiſton they acquire a phoſphoric quality when united with nitrous acid. *See* Phosphorus *of* Baldwin. A curious experiment is mentioned by Mr. Pott, which ſhewed this phoſphoric quality of calcareous earth united with nitrous acid. He ſaturated that acid with quicklime, and diſtilled it. He repeated this operation frequently, always uſing the ſame acid and the ſame quicklime. He perceived that the vapors which paſſed in theſe diſtillations through a hole in the receiver appeared luminous ſparks, which afterwards kindled, and flowed out like a ſtream of fire. He alſo perceived another remarkable circumſtance in this operation, namely, that the effervescence which happened on the mixing theſe two ſubſtances, became each time greater than it had been in the preceding experiment. Whence did the quicklime acquire the fixable air which cauſed theſe efferveſcences? Was it from the acid? *See* Pott's *Diſſertation on Quicklime.*

(a) *Calcareous earths may be combined* with acids, with which they form neutralized earthy ſalts. *See* Salts. They alſo readily unite with fixable air, in which ſtate of combination they are always found native. When uncombined with fixable air, or in the ſtate of quicklime, they may be combined with water, forming lime-water. *See* Water (Lime), Air (Fixable), Cream *of* Lime, *and* Quicklime. In this uncombined ſtate they alſo may be united in ſome degree with ſulphur, forming a kind of hepar of ſulphur, and imperfectly with oleaginous ſubſtances forming kinds of ſoaps.

Calcareous earth, although infuſible by fire (*ſee the above note* [y]), may be rendered fuſible and vitreſcible by addition of fixed alkaline ſalt, of borax, of ſedative ſalt, of ſalt of urine, of metallic calxes, of gypſeous and argillaceous earths, of fuſible ſpars, and according to Mr. Pott, of ſparry quartz, of glaſs-gall, and of fixed ammoniac. Mr. Gellert, in his Table of Solutions, places calcareous earth amongſt the ſubſtances incapable of uniting with gypſeous earths. Nevertheleſs, the experiments of Mr. Brandt and of Mr. D'Arcet evince the fuſibility of calcareous earths mixed with gypſum. This however may be obſerved, that I have found from experiments, that ſuch mixtures are fuſible only when expoſed ſuddenly to a violent fire; and that by a gradually raiſed fire they are calcinable into quicklime. The cauſe of which ſeems to be, that the vitriolic acid of the gypſum is neceſſary to the fuſion; and that this acid, by a long continued heat not ſufficiently intenſe to occaſion a fuſion of theſe two earths, may be diſſipated, leaving its calcareous baſis behind, which together with the calcined earth forms an unfuſible maſs or quicklime.

CCL. EARTH (MERCURIAL). Mercurial earth is a ſubſtance, which, according to Beccher and other chemiſts, enters into the compoſition of many bodies, particularly the metallic, together with *vitrifiable earth*, and phlogiſton, which that chemiſt calls the *inflammable earth*. But the exiſtence of this mercurial earth has not yet been ſatisfactorily demonſtrated. Metals and marine acid, of which alſo Beccher ſuppoſes the mercurial earth to be a conſtituent part, do indeed preſent ſome phenomena which may induce us to ſuſpect that theſe ſubſtances contain a principle different from all thoſe which we know. But theſe phenomena are not ſufficient to eſtabliſh with certainty the exiſtence of this principle. *See what is ſaid on this ſubject under the articles* ACID (MARINE), MERCURIFICATION, METALS, *and* METALLISATION.

CCLI. EARTH (VEGETABLE). (*b*)

CCLII. EARTH (VITRIFIABLE). The earth ſo called by chemiſts is the pureſt, ſimpleſt, and moſt elementary of all known earths. As we have mentioned all the eſſential properties of this earth under the general article EARTH, we refer for theſe properties to that article. We ſhall only obſerve here, that the ſtones formed principally by the union of the parts of this earth, and therefore called vitrifiable ſtones, are eaſily diſtinguiſhed from all the others by their hardneſs, which is ſo great, that they cannot be cut by ſteel tools, and that they can elicit ſparks from ſteel. They have alſo the property of giving ſparks of light when one of them is ſtruck againſt another; but it is then an internal fire, and ignited ſparks are not emitted, as when they are ſtruck by ſteel. This property of giving light by percuſſion alſo belongs to glaſs, porcelaine, and other vitrified matters. It ſeems to be a phenomenon depending on electricity.

(*b*) EARTH (VEGETABLE). From numerous experiments made by Wallerius we find that earths or aſhes of vegetables have not all the ſame chemical properties, but may be reduced into three kinds or claſſes. The firſt claſs is the earth obtained by burning ſoft, ſpongy, and farinaceous plants. It is partly ſoluble by vitriolic acids. It is more fuſible by fire in proportion as the plant from which it has been obtained was more nouriſhing. Thus the aſhes of rye, barley, oats, muſtard, and eſpecially thoſe of wheat and rice, were eaſily fuſible, forming green tranſparent glaſſes. This fuſion is not occaſioned by any mixture of alkaline ſalt, for no ſuch ſalt could be obtained from the aſhes of the above-mentioned grains by lixiviation. The ſecond claſs of vegetable earths is produced by burning the harder and leſs ſucculent plants. This earth is more ſoluble than the former in nitrous and marine acids, but is leſs ſoluble in vitriolic acid. This earth, after lixiviation, ſtill abſorbs moiſture from the air. It is alſo fuſible by fire, but not ſo eaſily as the former earth, and is leſs fuſible in proportion to the hardneſs of the plant. The third claſs of vegetable earth is that which is obtained by burning wood. This earth is calcareous, and is more difficultly fuſible in proportion as the wood from which it was obtained was harder. Accordingly, it has been obſerved by manufacturers of glaſs, that aſhes of the hardeſt woods make the moſt unfuſible glaſs. Garden mould, which conſiſts chiefly of the earth of decayed vegetables, was alſo found to be fuſible by fire. *See the Swediſh Memoirs for the year* 1760. By putrefaction of vegetable ſubſtances, a calcareous earth is ſaid to be obtainable.

Vitrifiable earth, when pulveriſed into very fine parts, and moiſtened with water, abſorbs but a very ſmall quantity of this liquid, and forms a paſte which has conſiderable adheſion, but no ductility. When it is made thin by water, it pours like an oily or viſcid matter: when it is of a thick conſiſtence, it does not preſerve the form given to it, but it ſinks and collapſes: it alſo dries very quickly and eaſily. If, on the contrary, this finely ground vitrifiable matter be left at reſt under water, its parts will unite and adhere together ſo ſtrongly, that a maſs ſhall be formed almoſt as hard as a ſtone. Hence when vitrifiable ſtones are ground with water, the matter muſt be continually agitated and ſtirred, and the mill muſt be turned without interruption; for if they are left but a little at reſt, they harden, and adhere ſo ſtrongly to the bottom of the mill, that the mill-ſtone cannot without difficulty be again ſet in motion. This inconvenience may be much diminiſhed by mixing the vitrifiable earth to be ground, with different earths, calcareous or argillaceous.

No vitrifiable ſtone or earth is ſoluble in any acid, unleſs its nature has been changed by having been intimately united with ſome other ſubſtance; as, for inſtance, by fuſion with a ſufficient quantity of fixed alkali: but it cannot then be conſidered as pure vitrifiable earth, as it has not then the properties of that earth.

As ſome ſtones externally reſemble vitrifiable ſtones, and which alſo reſiſt the action of acids, although they are not vitrifiable, the proof by acids is not ſufficient to aſcertain the nature of theſe ſtones. To this proof muſt alſo be added that of hardneſs, which is the moſt deciſive. Many impure and mixed vitrifiable earths and ſtones differ from each other by their colors, and other accidental particulars depending on the heterogeneous matters with which they are united.

Nature preſents to us many mixed earths and ſtones, or ſuch as are compoſed of many kinds of different earths, as the vitrifiable, calcareous, talky, argillaceous, gypſeous or ſelenitic, and even the pyritous or metallic. But we cannot enter into theſe details, which are the object of mineralogy. We ſhall obſerve, that when an accurate examination of theſe compound bodies is required, the nature and proportions of the component parts may be diſcovered by ſubmitting them ſucceſſively to the deciſive proofs which we have mentioned under the articles of the principal kinds of earths and ſtones, by which their nature may be diſcovered and aſcertained. *See in particular for the vitrifiable earths and ſtones, the general article* EARTH, *and the word* VITRIFICATION.

CCLIII. EARTH-WORMS. (*c*)

(*c*) EARTH-WORMS. Earth-worms, when moiſtened with wine, or with vinous ſpirits, to prevent their putrefaction, and ſet in a cellar in a wide-mouthed veſſel, are in a few days almoſt wholly reſolved into a ſlimy liquor. Stahl ſuppoſes that they are impregnated with a nitrous ſalt which they receive from the putrid matters amongſt which they live. When this liquamen of worms is mixed with a little fixed alkali, and, after the evaporation, is ſet to ſhoot, the cryſtals are nothing elſe than nitre. Six drams of extract were obtained by ardent ſpirit from four ounces of worms; and from the ſame quantity of theſe, one ounce, ſix drams, and a ſcruple of extract, by means of water. Thirty-two ounces of dried earth-worms yielded, by diſtillation, thirteen ounces and a half of volatile urinous ſpirit, one ounce of concrete volatile ſalt, four ounces and a half of empyreumatic oil, and eight ounces of a reſiduum, from which were obtained, by calcination and lixiviation, an ounce and a half of fixed alkali. *Neumann.*

CCLIV. EAU DE LUCE. Eau de luce is a kind of volatile, liquid ſoap, of a ſtrong, penetrating ſmell.

This liquor is compoſed of the liquid volatile alkali made from ſal ammoniac with quicklime, and of the rectified oil of amber, ſo mixed together as to produce a white milky liquor.

Eau de luce cannot be prepared without certain management; for if the volatile ſpirit of ſal ammoniac and rectified oil of amber be ſimply mixed and ſhook together, a milky liquor will be produced, ſuch as is required; but this color diſappears ſoon when the liquor is allowed to reſt; either becauſe the volatile alkali compleatly diſſolves the oil of amber when in ſmall quantity, or becauſe this oil diſengages itſelf from the volatile alkali, and floats a-part when in conſiderable quantity. In both caſes the liquor becomes clear and tranſparent; but the milky color is required in eau de luce. By the following receipt excellent eau de luce may be made.

Take four ounces of rectified ſpirit of wine, and in it diſſolve ten or twelve grains of white ſoap; filtrate this ſolution; then diſſolve in it a dram of rectified oil of amber, and filtrate again; mix as much of this ſolution with the ſtrongeſt volatile ſpirit of ſal ammoniac, in a cryſtal-glaſs bottle, as when ſufficiently ſhook, ſhall produce a beautiful milky liquor. If upon its ſurface be formed a cream, ſome more of the oily ſpirit of wine ought to be added.

This receipt is given by the author of the French edition of the London Diſpenſatory. The receipt given in that work is very good, but is much improved by the obſervations, experiments, and remarks made by that author.

CCLV. EDULCORATION. Edulcoration is, properly ſpeaking, the rendering ſubſtances more mild. Chemical edulcoration conſiſts almoſt always in taking acids and other ſaline matters from ſubſtances to which they adhere; and this is effected by waſhing in much water. The waſhing of diaphoretic antimony, and of the powder of algaroth, till the water comes off from theſe ſubſtances quite pure, may be given as inſtances of edulcoration.

In Pharmacy, juleps, potions, and other medicines, are ſaid to be *edulcorated*, by adding ſugar or ſyrup.

CCLVI. EFFERVESCENCE. Effervescence is an inteſtine motion excited betwixt the parts of two bodies of different natures, when they reciprocally diſſolve each other. Effervefcences are commonly accompanied with bubbles, vapors, ſmall jets of the liquid, and noiſe or hiſſing. All theſe phenomena are occaſioned by the air which diſengages itſelf in almoſt all ſolutions. Frequently alſo effervefcences are accompanied with a conſiderable heat, ſometimes exceeding that of boiling water. This heat is occaſioned by the colliſion of the parts during their union. The degree of heat produced in effervefcences is proportionable to the activity with which bodies are diſſolved, to the quickneſs with which the ſolution is made, and to the quantity of ſubſtances re-acting upon each other.

The moſt ſenſible effervefcences are obſerved in the combination of concentrated mineral acids with calcareous earths, alkaline ſalts, metallic ſubſtances, and oily matters.

Generally the ſubſtances which contain a ſenſible quantity of inflammable principle are thoſe which in ſimilar circumſtances produce the moſt heat in

effervefcing

effervescing with acids. Of all acids, the nitrous produces the greateſt heat, when it diſſolves theſe bodies.

Thus, for inſtance, the heat ariſing from a ſolution of calcareous earth in nitrous acid is not nearly ſo great as that which ariſes from a ſolution of a metallic ſubſtance in the ſame acid, although theſe ſolutions are performed equally faſt; and the heat which is produced by the combination of nitrous acid with oils is ſo great, that a flame is quickly produced.

Formerly the word *fermentation* was commonly applied to efferveſcences; but now that word is confined to the motion which is naturally excited in animal and vegetable matters, and from which new combinations amongſt their principles take place. This diſtinction is very proper; for a ſimple efferveſcence is very different from a true fermentation. *See* FERMENTATION.

CCLVII. EFFLORESCENCE. By this expreſſion chemiſts denote what happens to certain bodies, upon the ſurface of which a kind of meal or powder is formed.

Eﬄoreſcence is occaſioned either by decompoſition or by drying. That which happens to Cobalt, and moſt martial pyrites, is of the former kind; and the eﬄoreſcence obſerved on cryſtals of marine alkali, of Glauber's ſalt, of alum, of green and blue vitriols, and of ſeveral other ſalts, is of the latter kind.

CCLVIII. EGGS. The eggs of hens, of birds in general, and of ſeveral other animals, are compoſed of ſeveral diſtinct ſubſtances; 1. Of a ſhell or external coat, which in the eggs of birds has a certain hardneſs and conſiſtence, although it is brittle. The matter of this ſhell is a fine, abſorbent earth, ſoluble in acids; hence if theſe eggs be ſteeped in vinegar, or any other acid, they are rendered quite ſoft, becauſe the acid diſſolves and takes away all the earth of their ſhells. (*d*)

The parts of this earth are bound together by a ſmall quantity of gelatinous matter. This matter becomes very ſenſible by an empyreumatic animal ſmell, and by the black color which ſhells acquire when expoſed to fire.

The ſhell of an egg is lined internally with a very white, fine, and ſtrong membrane. It reſembles a very fine ſkin, and is entirely of animal nature.

Theſe external coverings contain the ſubſtance of the egg, which is of two kinds; namely, a lymphatic, white, tranſparent, gelatinous, viſcous, and gluey ſubſtance, called *the white of the egg*; and another ſubſtance alſo gelatinous, but almoſt opake, yellow, leſs gluey and viſcous than the white. This latter, which is called *the yolk*, is of a ſpherical form, and is ſurrounded by the white. To the yolk is annexed a ſmall portion of white gelatinous matter, thicker and tougher than the reſt of the white in which the embryo is contained.

We do not intend here to examine anatomically the uſes of theſe ſeveral parts of the egg; we will conſider them only relatively to their chemical properties and principles. As eggs contain the embryo of the animal, and the nouriſhment proper for it in its firſt increaſe, they are proper to give as an example of the analyſis of animal ſeed.

(*d*) The ſhells of eggs are not only abſorbent, that is, ſoluble by acids, but alſo calcareous, or convertible into quicklime. The earth of the ſhells, and alſo the earth obtained by calcination of the other parts of the eggs, are fuſible and vitreſcible by fire. *See* EARTH (ANIMAL).

The white of an egg cannot be diſſolved by acids or by ſpirit of wine. This latter ſolvent, far from dividing it, on the contrary coagulates it, by taking from it a great part of its water which renders it liquid.

The white of an egg is ſoluble and miſcible with water, but difficultly, becauſe of its viſcidity. Spirit of wine poured into water which keeps it diſſolved ſeparates it, and precipitates it in form of a curd. In this reſpect, the white of an egg reſembles gummy, mucilaginous, and gelatinous matters. It is, in fact, a matter entirely of the nature of animal jellies, but of that kind which are coagulable by heat. The white of an egg, expoſed to a leſs heat than that of boiling water, is coagulated, hardened, and its tranſparency is almoſt entirely changed to a milky-white color. This ſubſtance contains no other principles which are volatile with the heat of boiling water, than water; for if whites of eggs be diſtilled in a water-bath, nothing but water is obtained. While they loſe this water, they become more and more hard and horny; they reſume their tranſparency, and acquire a yellow-reddiſh color; ſo that when they are dried as much as poſſible, they perfectly reſemble horn.

If they are to be further analyſed, they muſt be put into a retort, and expoſed to a naked fire: then fetid empyreumatic oil with much volatile alkali is obtained; and in the retort, when the diſtillation is finiſhed, a coal is left like that of other animal matters. From this analyſis we ſee that the white of an egg is a perfectly animaliſed ſubſtance. *See* JELLY (ANIMAL).

The yolk of an egg is chiefly compoſed of a gelatinous matter like the white; for it alſo coagulates and hardens by heat; but it alſo contains a conſiderable quantity of mild fat oil, which is in ſome meaſure ſuperabundant, and not combined, and, in ſhort, in the ſame ſtate as thoſe oils which may be obtained from vegetable emulſive ſeeds by expreſſion. Thus the raw yolk of an egg when mixed with water is not entirely diſſolved, as the white is; but forms with it, on account of this oily part, a white milky liquor or emulſion. This animal emulſion is vulgarly called *hen's milk*.

This ſuperabundant oil of the yolk of an egg may be ſeparated from it, like that of moſt vegetable grains, by expreſſion. But to make this operation ſucceſsful, the yolk of an egg ought to be deprived as much as is poſſible of its water. For this purpoſe, the eggs are to be previouſly hardened, and the yolks are to be ſeparated, dried, and even roaſted in a proper veſſel, till they become ſomewhat ſoftened by the ſweating out of the oil; they are then to be put into a preſs, and a fat, unctuous, yellowiſh, and ſufficiently mild oil is procured, which readily fixes itſelf in the cold. This oil has the ſmell of roaſted or fried eggs, from the drying and roaſting given to the yolks before the expreſſion. Probably this oil might be obtained by a ſlower and more careful drying without roaſting, and conſequently without any change or ſmell.

From this quantity of ſuperabundant oil in yolks of eggs, we may perceive a remarkable reſemblance betwixt the eggs of animals and vegetable ſeeds. This oil is found in all ſeminal matters probably for the ſame reaſon. *See* OILS (SWEET EXPRESSED).

As all eggs in general are compoſed of a very nouriſhing ſubſtance, and that thoſe of many animals have a very agreeable taſte, they have been much uſed as aliment. They are alſo employed in medicine and in the arts. The white of an egg is an ingredient in collyriums and cataplaſms for diſeaſes of the eyes; and both the white and yolk in emollient and reſolvent cataplaſms. The oil of eggs is ſoftening, relaxing, and lubricating. It is employed either ſingly, or formed into a pomatum with fat matters, in burns, chaps, contractions, and other ſimilar diſeaſes.

The white of an egg, from its ſolubility in water, and from its coagulating by fire or in ſpirituous liquors, is very ſucceſsfully employed in pharmacy, for many uſes of the kitchen, and for clarifying the juices of plants, whey, ſugar, ſyrups, &c. *See* FILTRATION.

The white of an egg alone forms a varniſh very white and very ſhining, which is applied to ſeveral kinds of work, and particularly to pictures. Laſtly, the yolk of an egg, from its oily and viſcid parts, is a proper intermediate ſubſtance for the mixture by trituration of oils with watery liquors, ſo as to form emulſions. Several good remarks are found upon this ſubject in Mr. Beaumé's Treatiſe on Pharmacy. *(e)*

CCLIX. ELECAMPANE. *(f)*

CCLX. ELEMENTS. Thoſe bodies are called by chemiſts *elements*, which are ſo ſimple, that they cannot by any known method be decompoſed, or even altered; and which alſo enter as principles, or conſtituent parts, into the combination of other bodies, which are therefore called compound bodies.

The bodies in which this ſimplicity has been obſerved are fire, air, water, and the pureſt earth; for by the moſt complete and accurate analyſes which have been made, nothing has been ever ultimately produced but ſome one, or more, of theſe four ſubſtances, according to the nature of the decompoſed bodies.

Theſe ſubſtances, although reputed ſimple, may poſſibly not be ſo, and may even reſult from the union of ſeveral other more ſimple ſubſtances: but as experience teaches us nothing on this ſubject, we may without inconvenience, and we ought to conſider, in chemiſtry, fire, air, water, and earth, as ſimple bodies; becauſe they really act as ſuch in all chemical operations.

The elements are alſo called by chemiſts *primary principles*. *See* PRINCIPLES, FIRE, AIR, WATER, and EARTH.

CCLXI. ELIQUATION. *(g)*

CCLXII. ELUTRIATION. *(h)*

(e) Mr. Reaumur found that eggs might be preſerved during months or years, by being covered with mutton ſuet, or any other fat ſubſtance; which, by filling up the pores of the ſhell, excluded the air, which is neceſſary to putrefaction.

(f) ELECAMPANE. From thirty-two ounces of the roots of elecampane were obtained, by diſtillation, three ſcruples and a half of concrete oil, ſimilar in many, but not in all its properties to camphor. This concrete oil is ſoluble in ſpirit of wine. Geoffroy remarks, that it reſides in the exterior part of the root, near to the bark. From an ounce of the dry root ſix drams and a half of extract may be obtained by water, and from the ſame quantity two drams and a half by ſpirit. *Neuman.*

(g) ELIQUATION. This is an operation by which a more fuſible ſubſtance is ſeparated from one leſs fuſible, by means of a heat ſufficiently intenſe to melt the former, but not the latter. Thus an allay of copper and lead may be ſeparated by applying a heat which ſhall melt the lead, but not the copper.

(h) ELUTRIATION is an operation performed by waſhing ſolid ſubſtances with water, ſtirring them well together, and haſtily pouring off the water, while the lighter part remains ſuſpended in the agitated water, that it may be thereby ſeparated from the heavier part. By this operation metallic ores are cleanſed from earth, ſtones, and other lighter unmetallic particles adhering to them.

CCLXIII. EMERALD. (i)

CCLXIV. EMERY. (k)

CCLXV. EMPYREUMA. Empyreuma is a ſmell proceeding from burnt animal and vegetable matters, when they are expoſed to a quick fire, particularly in cloſe veſſels.

Empyreuma is the peculiar ſmell of burnt oils. No other but oily ſubſtances can produce it. As all vegetable and animal matters contain oil, and as no other ſubſtance contains it, hence the empyreumatic ſmell muſt be peculiar to burnt animal and vegetable matters; and hence alſo we may diſcover oil wherever it may be by this ſmell, which is ſo diſtinguiſhable, that it is very ſenſible even when the quantity of oil is too ſmall to be diſcovered by any other method. If then we perceive an empyreumatic ſmell when we burn a ſubſtance in cloſe veſſels, we may conclude that this ſubſtance contains oil. If, on the contrary, no empyreuma be perceived, we may be aſſured that the ſubſtance does not contain oil.

CCLXVI. EMULSION. An emulſion is a watery liquor, in which ſome oily matter is diſperſed and diffuſed (but not diſſolved), by the intervention of a mucilaginous or gelatinous ſubſtance.

The ſtate of the oil in emulſions is the cauſe why they are opake, and of a milky-white color; for this milky appearance is given to all tranſparent bodies by others that have not a very diſtinct color, when they are mutually interpoſed and divided to a certain degree.

Nevertheleſs, water and oil ſlightly adhere together in emulſions, by the intervention of the mucilaginous matter; for oil agitated with water gives but a momentary appearance of an emulſion, and only during the agitation. When it is left to reſt, the oil preſently riſes to the ſurface.

All vegetable and animal ſubſtances containing an uncombined oil, and mucilage or jelly, being triturated with water, yield emulſions.

Moſt ſeeds and grains, all gum-reſins, gummy and reſinous juices, and yolks of eggs, are capable of forming emulſions with water. Laſtly, the milky juices of plants, milk, and the chyle of animals, ought to be conſidered as natural emulſions.

(i) **Emerald**, *Smaragdus*, is a precious ſtone, contained by ſeveral unequal ſides and obtuſe angles, forming irregular priſms. Its color is green: with a moderately ſtrong heat it becomes blue, but recovers its original green color when cold. By expoſure to collected ſolar heat, emeralds were rendered white and of various colors, and ſoon afterwards were fuſed, by which they loſt part of their weight and hardneſs. See **Diamonds**. Emeralds have the property of ſhining in the dark after having been heated. They are the fourth in hardneſs from diamonds; nevertheleſs they are ſuſceptible of impreſſion from a file. Emeralds may be imitated by adding forty-eight grains of pulverifed calcined verdegriſe, and eight grains of martial crocus, to four ounces of minium and two ounces of pure rock-cryſtal, previouſly calcined and levigated, and by keeping that mixture fuſed during twenty-four hours.

(k) **Emery.** *Smiris.* Emery is a very refractory mineral containing a ſmall portion of iron. It is exceedingly hard, and is therefore uſed for the poliſhing of metals, glaſs, and hard ſtones. Some pieces of emery contain ſmall ſpecks of gold, and of copper. The mineral called by alchemiſts *ſmiris Hiſpanica*, and employed to adulterate gold, is with probability believed to be the metal now called platina.

CCLXVII. ENAMEL. Enamel is in general a vitrified matter, betwixt the parts of which is diſperſed ſome unvitrified matter: hence enamel ought to have all the properties of glaſs excepting tranſparency. Enamels then are opake glaſſes, and their opacity and colors proceed from the unvitrified matter which they contain. The unvitrified matters which give opacity and various colors to enamels, are almoſt always metallic calxes. Receipts for making ſeveral kinds of enamel may be found in ſeveral books, particularly in Neri's Treatiſe on the Art of Making Glaſs, with Notes by Merret and Kunkel.

Enamels ought to be very fuſible. They are employed to color or to paint ſeveral kinds of work which are made by great heat. The white enamel is uſed to cover the earthen ware called *Delf*, to which it gives the appearance of porcelain. With the other colored enamels this Delf ware, porcelain, and alſo the white enamel, are painted. *See* DELF-WARE. *(l)*

CCLXVIII. ENS MARTIS, and ENS VENERIS. Theſe Latin names are given to the flowers of iron and of copper made with ſal ammoniac, or rather to theſe two metals ſublimed by this ſalt. *See* FLOWERS.

(*l*) Enamels are glaſſes containing ſome opake ſubſtance, that is either unvitrifiable or incapable of being vitrified with the degree of heat requiſite for the fuſion of ordinary glaſs. Of the latter ſort are almoſt all the enamels uſed, they being moſtly compoſed of glaſs mixed with metallic calxes; all which, not excepting the calx of tin, by more intenſe heat might be reduced to tranſparent glaſſes. The white vitreous compoſition which is the baſis of all enamels is prepared, according to Neri, by melting together a hundred parts of frit of calcined flints, one part of pure ſalt of tartar, and a hundred parts of a calx of lead and tin. This calx is prepared by calcining together equal parts of tin and lead, and reducing the ſubſtance ſo calcined to a very fine powder, by bruiſing it, paſſing it through a ſieve, boiling it in water, decanting the water in which the finer parts are ſuſpended, evaporating the water, and drying the powder; and by repeating the calcination and ſubſequent operations upon the groſſer particles, till they become as fine as the former. This compoſition when ſlightly fuſed is to be reduced to a powder, and formed into all the various colored enamels, by adding to it coloring ſubſtances. Thus by adding to ſix pounds of this compoſition, forty-eight grains of magneſia, a *fine white enamel* may be prepared; an *azure blue enamel*, by adding to the ſame quantity three ounces of zaffre, and ſixty grains of calcined copper; a *turquois blue enamel*, by adding three ounces of calcined copper, ninety-ſix grains of zaffre, and forty-eight grains of magneſia; a *green enamel*, by adding three ounces of calcined copper and ſixty grains of ſcales of iron; a *ſhining black enamel*, by adding three ounces of zaffre and as much magneſia, or by adding ſix ounces of red tartar and three ounces of the ſame magneſia; a *purple enamel*, by adding three ounces of magneſia; a *yellow enamel*, by adding three ounces of tartar and ſeventy-two grains of magneſia; *a ſea-green or beryl-colored enamel*, by adding three ounces of calcined braſs and ſixty grains of zaffre; and a *violet-colored enamel*, by adding two ounces of magneſia and forty-eight grains of calcined copper. Theſe are the receipts given by Neri, approved by Kunkel, and now ſucceſsfully uſed. The intenſity and continuance of the heat muſt be attended to, as the colors both of enamels and of the tranſparent glaſſes imitating colored precious ſtones, eſpecially of thoſe which contain magneſia, depend much on theſe circumſtances. White enamels may be compoſed of other ſubſtances beſides calx of tin. Merret propoſes to ſubſtitute regulus of antimony. Calcined bones, and perhaps other white earths, may be uſed for the ſame purpoſe. Mr. D'Arcet found that gypſum mixed with white clay, or with clay and hard ſpar, formed very beautiful enamels. Perhaps ſome of theſe enamels would form preferable glazings to that made with calx of tin, for covering thoſe kinds of earthen ware which require, in the baking, greater heat than is ſuitable to the common enamel.

CCLXIX. ESSAY. Eſſays are chemical operations made in ſmall, to determine the quantity of metal or other matter which is contained in minerals, or to diſcover the value or purity of any maſs of gold or ſilver.

We ſhall treat ſucceſſively of each kind of eſſay.

CCLXX. ESSAY *of* ORES. Before eſſays of ores can be well made, a preliminary knowledge of the nature of the ſeveral metallic minerals ought to be attained. Each metal has its proper and improper ores, which have peculiar characters and appearances: hence perſons, accuſtomed to ſee them, know pretty nearly, by the appearance, weight, and other obvious qualities, what metal is contained in a mineral. A good eſſayer ought to be very intelligent in this matter, that he may at once know what the proper operations are which are requiſite to the eſſay of any given mineral. Some remarks may be found on this ſubject under the article ORES.

As metals are very unequally diſtributed in their ores, we ſhould be apt to make falſe and deceitful eſſays, if we did not uſe all poſſible precautions that the proportionable quantity of metal produced by any eſſay ſhall be nearly the medium contained in the whole ore. This is effected by taking pieces of the mineral from the ſeveral veins of the mine, if there be ſeveral, or from different places of the ſame vein. All theſe minerals are to be ſhook together with their matrixes. The whole is to be well mixed together, and a convenient quantity of this mixture is to be taken for the eſſay. This is called the *lotting* of the ore.

As eſſays, particularly the firſt, are generally made in ſmall, eſſayers have very ſmall weights correſponding to the weights uſed in the great, that is, to the quintal or hundred pounds weight, to pounds, ounces, drams, &c. The eſſay quintal and its ſubdiviſions vary according to the difference of weights in different countries, and this occaſions ſome confuſion, when theſe weights are to be adjuſted to each other. Tables of theſe weights are found in treatiſes of eſſaying, and particularly in that written by Schlutter, and tranſlated and rendered more complete by Hellot, which contains all the details neceſſary for the ſubject.

The cuſtom is to take, for the eſſay quintal, a real weight of a gros, or dram, which in France is equal to 72 grains; but as the whole dram repreſents 100 pounds, each grain repreſents a pound and a fraction of a pound; and hence ſome difficulty and confuſion ariſe in making the ſubdiviſions. A better method is that of Mr Hellot, which is to make the fictitious or eſſay quintal equal to a hundred real grains, and then each grain repreſents a real pound. This eſſay quintal is ſufficiently exact for ores of lead, tin, copper, iron, antimony, biſmuth, and mercury. But for ores of ſilver and gold another repreſentation is convenient; for theſe metals, as Mr. Hellot ſays, are generally in ſo ſmall quantity, that the button or ſmall piece of metal obtained in the eſſay could not be accurately weighed, if a hundred real grains were made to repreſent a quintal; and the difficulty of ſeparating the gold from ſo ſmall a quantity would be ſtill greater. Theſe motives have induced Mr. Hellot to uſe for theſe ores a fictitious quintal ſixteen times bigger, that is, equal to 1600 real grains, which repreſent 1600 ounces, that is, 100 lb. or quintal. The ounce being repreſented by a grain, its ſeveral ſubdiviſions muſt be repreſented by fractions of a grain.

Thus 12 grains of the fictitious quintal correſpond with $\frac{5}{48}$ of a real grain (*m*); and this latter quantity may be accurately weighed in eſſay ballances, which when well made, are ſenſible to a much leſs weight.

When a quintal of an ore to be eſſayed has been weighed, and lotted, as we deſcribed above, it is to be roaſted in a teſt under a muffle. It is to be waſhed, if neceſſary; and, in ſhort, the ſame operations are to be made in ſmall which are uſually done in great. Additions alſo are to be made, and in proper proportions, according to the peculiar nature of the ore. The fluxes generally mixed with the ore in eſſays are three, four, or five parts of black flux; one, two, or three parts of calcined borax; and one half of that quantity of decrepitated common ſalt. The more refractory the ore is, the more neceſſary is the addition of theſe fluxes: then the whole mixture is to be fuſed either in a forge, or in a melting or eſſay furnace.

To make eſſays well, all poſſible attention and accuracy are to be employed. This object cannot be too much attended to; for the leaſt inaccuracy in weighing, or loſs of the ſmalleſt quantity of matter, might cauſe errors, ſo much greater, as the diſproportion betwixt the weights employed and thoſe repreſented is greater. The moſt minute accuracy therefore is neceſſary in theſe operations. For inſtance, the eſſay ballances ought to be ſmall, and exceedingly juſt. The ore ought not to be weighed till it has been reduced to groſs powder fit for roaſting; becauſe ſome of it is always loſt in this pulverization. When the ore is roaſted, it ought to be covered with an inverted teſt; becauſe moſt ores are apt to crackle and diſperſe, when firſt heated. To make the fuſion good and compleat, the preciſe degree of fire which is requiſite ought to be employed; and when it is finiſhed, the crucible ought to be ſtruck two or three times with ſome inſtrument to facilitate the diſengagement of the parts of the regulus from the ſcoria, and to occaſion their deſcent and union into one button of metal. The crucible ought not to be broken, nor its contents examined till it is perfectly cold.

Upon breaking the crucible, we may know that the fuſion has been good, if the ſcoria be neat, compact, and equal; if it has not overflowed or penetrated the crucible; if it contain no metallic grains; and if its ſurface be ſmooth, and hollowed in the middle. The regulus or button ought to be well collected, without holes, or bubbles, and to have a neat convex ſurface; it is then to be ſeparated from the ſcoria, well ſcraped and cleaned; and, laſtly, is to be weighed. If the operation has been well made, its weight ſhows the quantity of metal which every real quintal of ore will yield in the great. If the perfect ſucceſs of this eſſay be in any reſpect doubtful, it ought to be repeated; but the beſt method at all times is to make ſeveral eſſays of the ſame ore. Some ſmall differences are always found, however well the eſſays may have been made. By taking the medium of the reſults of the ſeveral operations, we may approach, as nearly as poſſible, the true product of the ore.

Laſtly, as mines are not worked, nor founderies eſtabliſhed (which cannot be done without conſiderable expence) till the ore has been eſſayed, ten or twelve

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(*m*) The pounds, of which a hundred are here ſuppoſed to make a quintal, are called Paris pounds, one of which contains 9216 troy grains. *See* WEIGHT.

real pounds of the ore ought to be previouſly eſſayed; and eſſayers ought to be furniſhed with neceſſary furnaces and inſtruments for theſe larger eſſays.

We now proceed to give ſome examples of eſſays of ores. To eſſay a lead ore, for inſtance, which is not very refractory, let one or more quintals of this ore be groſly powdered, and roaſted in a teſt till no more ſulphureous vapors be exhaled, and then reduced to a finer powder; it is then to be accurately mixed with twice its weight of black flux, a fourth part of its weight of clean filings of iron and of borax. Theſe proportions are given by Mr. Cramer. The mixture is to be put into a good crucible, or rather into a teſt; it is then to be covered with a thickneſs of two or three fingers of decrepitated ſea-ſalt; the crucible is to be cloſed, and placed in a melting furnace, which is to be filled with unlighted charcoal, ſo that the top of the crucible ſhall be covered with it. Lighted coals are then to be thrown upon the unkindled charcoal, and the whole is left to kindle ſlowly, till the crucible be red-hot; ſoon after which a hiſſing noiſe proceeds from the crucible, which is occaſioned by the reduction of the lead: the ſame degree of fire is to be maintained while this noiſe continues; and is afterwards to be ſuddenly encreaſed, ſo as to make a perfect fuſion; in which ſtate it is to be continued during a quarter of an hour; after which it is to be extinguiſhed; and the operation is then finiſhed.

The filings of iron are added to the mixture, to abſorb the ſulphur, a certain quantity of which generally remains united with the lead ore, notwithſtanding the roaſting. We need not fear leſt this metal ſhould unite with the lead and alter its purity; becauſe although the ſulphur ſhould not hinder it, theſe two metals cannot be united. The refractory quality of the iron does not impede the fuſion; for the union it forms with the ſulphur renders it ſo fuſible, that it becomes itſelf a kind of flux.

This addition of iron in the eſſay of lead ores would be uſeleſs, if the ores were ſufficiently roaſted, ſo that no ſulphur ſhould remain.

Lead ores generally contain ſome ſilver, and ſometimes a conſiderable quantity of it; wherefore, after the ore has been eſſayed, and the regulus of lead collected and weighed, it ought to be teſted, to diſcover the quantity of ſilver it contains; and as ſometimes theſe lead ores contain alſo gold, the button of ſilver remaining upon the cupel ought to be eſſayed by parting, to aſcertain the quantity of gold, if there be any.

The details for the eſſays of all other ores and minerals are too numerous to be inſerted in this work. They are themſelves the ſubject of ſeveral books, which may be conſulted. The beſt of theſe books are Cramer's Art of Eſſaying, (*Ars Docimaſtica*), and Schlutter's Work tranſlated into French by Mr. Hellot. We ſhall find many things relating to this matter under the articles, ORES, SMELTING *of* ORES. (*n*)

(*n*) The eſſaying of ores is a matter of ſuch importance to chemiſtry, to arts, and to the wealth of nations, that we ſhall endeavor to ſupply what the author of the Dictionary has omitted on this ſubject, by adding to the ſeveral articles of the ores of metals the methods of eſſaying theſe ores. *See* ORES. We ſhall here only obſerve in general, that the methods generally practiſed for eſſay ores of imperfect metals, and ſemimetals pecially, are inſufficient to procure the whole quantity of metal contained in ores, or even ſo much as is obtained in the ſmelting of large quantities of ores; and that therefore the reſult of eſſays is not to be conſidered as the preciſe quantity contained in an ore, but generally

CCLXXI. ESSAY *of the* VALUE *of* SILVER, to examine its purity, or the quantity of alloy mixed with it. The common method of examining the purity of ſilver, is by mixing it with a quantity of lead proportionable to the quantity of imperfect metals with which it is ſuppoſed to be alloyed; by teſting this mixture; and afterwards by weighing the remaining button of ſilver. The loſs of weight which the ſilver ſuffers by cupellation ſhews the quantity of imperfect metals which it contained.

We may hence perceive, that the eſſay of ſilver is nothing elſe than the refining of it by cupellation. The only difference betwixt theſe two operations is, that when ſilver is teſted merely for the purpoſe of refining it, its value is generally known; and it is therefore mixed with the due proportion of lead, and teſted without any neceſſity of attending to the loſs of weight it ſuſtains during the operation; whereas in the eſſay all poſſible methods ought to be employed to aſcertain preciſely this loſs of weight. The firſt of theſe operations, or the mere refining of ſilver, is made in the great, in the ſmelting of ſilver ores, and in mints for making money. *See* REFINING. The ſecond operation is never made but in ſmall; becauſe the expences of ſmall operations are leſs than of great, and the requiſite accuracy is more eaſily attended to. The laſt operation is our preſent ſubject, and is to be performed in the following manner.

We ſuppoſe, firſt, that the maſs or ingot of ſilver, of which an eſſay is to be made, conſiſts of twelve parts perfectly equal, and theſe twelve parts are called penny-weights. Thus if the ingot of ſilver be an ounce weight, each of theſe twelve parts will be $\frac{1}{12}$ of an ounce; or if it be a mark, each of theſe will be $\frac{1}{12}$ of a mark, &c. Hence if the maſs of ſilver be free from all allay, it is called ſilver of twelve penny-weights; if it contains $\frac{1}{12}$ of its weight of allay, it is called ſilver of eleven penny-weights; if $\frac{2}{12}$ of its weight be allay, it is called ſilver of ten penny-weights; and theſe ten penny-weights or parts of pure ſilver are called *fine penny-weights*.

We ought to obſerve here concerning theſe penny-weights, that eſſayers give alſo the name *penny-weight* to a weight equal to twenty-four real grains; which latter real penny-weight muſt not be confounded with the former, which is only ideal and proportional; and ſuch a confuſion is the more likely to take place, as this

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generally only as an inaccurate approximation to that quantity. Mr. Gellert aſcribes one cauſe of the want of ſucceſs of theſe operations to the alkaline ſalts employed as fluxes to the ores, by which moſt metallic calxes are partially ſoluble, but more eſpecially ſo, when any of the ſulphur of the ore remains; which, by uniting with theſe ſalts, forms a hepar of ſulphur, which is the moſt powerful of all ſolvents. He propoſes therefore to omit the black flux, and other alkaline ſalts, and to add nothing to the ore but powder of charcoal, and ſome fuſible glaſs. This method, he ſays, he learned from Mr. Cramer, and has himſelf uſed with much ſucceſs in the eſſays of iron and copper: but finding that other imperfect metallic ſubſtances could not ſuſtain the heat neceſſary to effect the fuſion and vitrification of the unmetallic parts of the ore without being partly diſſipated, he found it neceſſary to add in the eſſays of theſe latter metallic matters ſome borax, by which the fuſion might be completed with leſs heat. As we conſider this as a conſiderable improvement in the art of eſſaying ores, we ſhall, to the articles of the ſeveral ores, add not only the proceſſes commonly preſcribed, but alſo theſe of Mr. Gellert, according to the method here mentioned. I have ſometimes eſſayed ores very ſucceſsfully by this method, from which I could obtain little, if any metal, by means of the black flux. *See* ORES.

ideal penny-weight is alſo, like the former, divided into twenty-four ideal grains, which are called *fine grains.*

An ingot of fine ſilver, or ſilver of twelve penny-weights, contains then 288 fine grains; if this ingot contains $\frac{1}{288}$ part of allay, it is ſaid to be ſilver of eleven penny-weight and twenty-three grains; if it contains $\frac{2}{288}$ of allay, it is called ſilver of eleven penny-weight and twenty-two grains; if it contains $\frac{14}{288}$, it is called ſilver of eleven penny-weight and ten grains; and ſo on. Laſtly, the fine grain has alſo its fractions, as $\frac{1}{2}$, $\frac{1}{4}$ of a grain, &c.

As eſſays to diſcover the value of ſilver are always made in ſmall, eſſayers only take a ſmall portion of an ingot for the trial, and the cuſtom in France is to take thirty-ſix real grains for this purpoſe, which is conſequently the largeſt weight they employ, and repreſents twelve fine penny-weights. This weight is ſubdivided into a ſufficient number of other ſmaller weights, which alſo repreſent fractions of fine penny-weights and grains. Thus eighteen real grains, which is half of the quantity employed, repreſent ſix fine penny-weights; three real grains repreſent one fine penny-weight, or twenty-four fine grains; a real grain and a half repreſent twelve fine grains; and $\frac{1}{32}$ part of a real grain repreſents $\frac{1}{4}$ part of a fine grain, which is only $\frac{1}{1152}$ part of a maſs of twelve penny-weights.

We may eaſily perceive that weights ſo ſmall, and eſſay balances, ought to be exceedingly accurate. Theſe balances are very ſmall, ſuſpended and incloſed in a box the ſides of which are panes of glaſs, that they may be preſerved from duſt, and that their motion may not be affected by agitated air, ſo as to diſorder their action.

When an eſſay of a maſs or ingot of ſilver is to be made, the cuſtom is to make a double eſſay. For this purpoſe, two fictitious ſemi-marks, each of which may be equal to thirty-ſix real grains, are to be cut from the ingot. Theſe two portions of ſilver ought to be weighed very exactly; and they ought alſo to have been taken from oppoſite ſides of the ingot.

Perſons accuſtomed to theſe operations know pretty nearly the value of ſilver merely by the look of the ingot, and ſtill better by rubbing it on a touchſtone. By the judgment they form of the purity of the ingot, they regulate the quantity of lead which is to be added to it, as this quantity muſt be always proportionable to the quantity of imperfect metal mixed with the ſilver.

Nevertheleſs, this proportion of lead to the alloy has not been preciſely determined. Authors who treat of this ſubject differ much. They who direct the largeſt quantity of lead ſay, that thereby the alloy is more certainly deſtroyed; and others who direct a ſmall quantity of lead pretend, that no more of that metal ought to be uſed than is abſolutely neceſſary, becauſe it carries off with it always ſome portion of ſilver. Every eſſayer uſes his own particular method of proceeding, to which he is attached.

To aſcertain theſe doubtful points, three chemiſts of the Academy of Sciences at Paris, Meſſrs. Hellot, Tillet, and Macquer, were appointed by the French Government. They were directed to aſcertain every thing concerning the eſſay of gold and of ſilver by authenticated experiments, made under the inſpection of a miniſter whoſe ſuperior knowledge is equal to his deſire of public good, and in preſence of the officers of the mint.

It appeared that the beſt proportions were, to add from two to three parts of lead to one part of ſilver of eleven penny-weights, and twenty-three grains value, that is, which contains $\frac{1}{288}$ of alloy; from four to ſix parts of lead to one part of ſilver of eleven penny-weight, twelve grains value, or which contains $\frac{1}{24}$ of alloy, which is nearly the value of ſilver employed for plate; from ſix to eight parts to one part of ſilver of eleven penny-weight, which contains $\frac{1}{12}$ of alloy, ſuch as that of ſilver coin; and ſo on in proportion. (*o*)

Two cupels of equal ſize and weight are to be choſen. The cuſtom is to uſe cupels of ſuch a ſize that their weight ſhall be equal to that of one half of the lead employed in the eſſay; becauſe ſuch cupels have been found capable of imbibing all the litharge formed during the operation. Theſe cupels are to be placed together under a muffle in an eſſay-furnace. The fire is to be kindled, and the cupels to be made red-hot, and to be kept ſo during half an hour at leaſt before any metal be put into them. This precaution is neceſſary to dry and calcine them perfectly; becauſe if they contained any moiſture or inflammable matter, an ebullition and efferveſcence would be occaſioned in the eſſay. When the cupels are heated ſo as to become almoſt white, the lead is to be put into them; the fire is to be encreaſed, which is done by opening the door of the aſh-hole ſo as to admit air, till the lead becomes red, ſmoking, and is agitated by a motion of its parts called its *circulation*, and till its ſurface becomes ſmooth and clear.

Then the ſilver previouſly beat into ſmall plates, for its eaſier fuſion, is to be put into the cupels; the fire is to be continued, and even encreaſed, by putting hot coals at the mouth of the muffle, till the ſilver ſhall have *entered the lead*, that is, till it have melted and mixed with the lead. When the melted matter circulates well, the heat is to be diminiſhed by taking away, partly or entirely, the coals put at the mouth of the muffle, and by cloſing more or leſs the doors of the furnace.

The heat ought to be regulated ſo, that the eſſays in the cupels ſhall have ſurfaces ſenſibly convex, and ſhall appear ardent, while the cupels are leſs red; that the ſmoke ſhall riſe almoſt to the roof of the muffle; that undulations ſhall be made in all directions upon the ſurfaces of the eſſays, which are called *circulations*; that their middles ſhall be ſmooth and ſurrounded with a ſmall circle of litharge, which is continually imbibed by the cupels.

The eſſays are to be kept in this ſtate till the operation is finiſhed, that is, till the lead and alloy have ſoaked into the cupel; and the ſurfaces of the buttons of ſilver being no longer covered with a pellicle of litharge, become

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(*o*) The imperfect metals are deſtructible by ſcorification with lead; but when they are allayed with ſilver or gold, a larger quantity of lead is required to produce the ſcorification of any given quantity of imperfect metals, than when they are not allayed and defended from the action of the lead and fire by mixture with the perfect metals. And further, the quantity of lead requiſite for this purpoſe muſt be encreaſed, when the quantity of ſilver or gold, with which the given quantity of imperfect metal is allayed, is encreaſed. Thus, for inſtance, an ounce of pure copper may be conſumed by ſixteen ounces of lead. But if an ounce of copper be allayed with eight ounces of ſilver, about ſix times the above quantity of lead, or ninety-ſix ounces, will be required to deſtroy the ounce of copper; and if the ounce of copper be mixed with thirty-ſix times its weight of ſilver, its ſcorification will require 128 ounces of lead. The quantity of lead muſt be ſtill further encreaſed for another reaſon, namely, that almoſt all lead, as Cramer ſays, contains ſome portion of copper.

ſuddenly bright and ſhining, and are then ſaid to *lighten*. If the operation has been well conducted, the two eſſays ought to become bright nearly at the ſame time. When the ſilver has been by this operation well refined, we may ſee, immediately after it has brightened, the ſurface of the ſilver covered with rainbow colors, which quickly undulate and croſs each other, and then the buttons become fixed or ſolid.

The management of the fire is an important article in eſſays. For if the heat be too great, the lead is ſcorified and imbibed by the cupel ſo quickly, that it has not ſufficient time to ſcorify and carry along with it all the alloy ; and if the heat be too little, the litharge is gathered upon the ſurface, and does not penetrate the cupel. The eſſayers ſay then that the eſſay is *choaked* or *drowned*. In this caſe the eſſay does not advance, becauſe the litharge covering the ſurface of the metal defends it from the contact of air, which is abſolutely neceſſary for the calcination of metals. *See* CALCINATION *and* COMBUSTION.

We have above related the marks of a ſucceſsful eſſay. The heat may be known to be too great, from the convexity of the ſurface of the melted metal ; from a too ſtrong circulation ; from the too vivid appearance of the cupel, ſo that the colors given to it by the litharge cannot be diſtinguiſhed ; and laſtly, by the ſmoke riſing up to the roof of the muffle, or not being at all viſible, from its being ſo ardent and red-hot as not to be diſtinguiſhable. In this caſe the heat muſt be diminiſhed by ſhutting the door of the aſh-hole : Some eſſayers, for this purpoſe, put round the cupels ſmall, oblong, cold pieces of baked clay, which they call *inſtruments*.

If on the contrary, the melted metal have a ſurface not very ſpherical, relatively to its extent ; if the cupel appear dark colored, and the ſmoke of the eſſay do only creep upon the ſurface ; if the circulation be too weak, and the ſcoria which appears like bright drops have but a dull motion, and are not ſoaked into the cupel ; we may be aſſured that the heat is too weak ; much more may we be aſſured of it when the metal *fixes*, as the eſſayers call it. In this caſe, the fire ought to be encreaſed by opening the door of the aſh-hole, and by placing large burning coals at the mouth of the muffle, or even by laying them acroſs upon the cupels.

As ſoon as the lead is put into the cupels, the fire is to be encreaſed, becauſe they are then cooled by the cold metal, and the lead ought to be quickly melted, to prevent its calx from collecting upon its ſurface in too great quantity before it be formed into litharge ; which it would do, and be difficultly fuſed, if the heat were too weak.

When the ſilver is added to the lead, the heat muſt be ſtill encreaſed, not only becauſe the ſilver cools the maſs, but becauſe it is leſs fuſible than lead. And as all theſe effects ought to be produced as quickly as poſſible, more heat is at length given than ought to be continued ; and therefore, when the ſilver has entered the lead, the heat is to be diminiſhed till it becomes of a due intenſity for the operation.

During the operation the heat ought gradually to be augmented to the end of it, both becauſe the metallic mixture becomes leſs fuſible as the quantity of lead diminiſhes, and alſo becauſe the lead is more difficultly ſcorifiable, as it is united with a larger proportion of ſilver. Hence the eſſays muſt be rendered very hot before they brighten.

When the operation is finiſhed, the cupels are left in the ſame heat during ſome ſeconds, to give time to the laſt portions of litharge to be entirely abſorbed; becauſe if any of it remained under the buttons of ſilver, it would ſtick to them. The fire is then allowed to extinguiſh, and the cupels to cool gradually, till the buttons have entirely fixed, particularly if they be pretty large; becauſe if they cool too quickly, their ſurfaces fix and contract before the internal maſs, which is thereby ſo ſtrongly compreſſed as to burſt through the external ſolid coat and form vegetations, or even to be entirely detached from the reſt of the maſs and diſſipated. This is called *the vegetation of the button.* It ought to be carefully prevented, becauſe ſmall bits of ſilver are ſometimes thrown out of the cupel.

Laſtly, when the buttons are thoroughly fixed, they are to be diſengaged from the cupels by a ſmall iron utenſil while they are yet hot, otherwiſe they could not be diſengaged clean and free from part of the cupels which ſtrongly adhere to them when the heat is much diminiſhed.

Nothing then remains to compleat the eſſay but to weigh the buttons. The diminution of weight which they have ſuſtained by cupellation will ſhow the purity or value of the ingot of ſilver.

We ought to obſerve, that as almoſt all lead naturally contains ſilver, and that after cupellation this ſilver is mixed with the ſilver of the ingot in the button of the eſſay; before we employ any lead in this operation, we ought to know how much ſilver it contains, that we may ſubtract this quantity from the weight of the button, when we compute the fineneſs of the ſilver of the ingot eſſayed. For this purpoſe eſſayers generally cupel a certain quantity of their lead ſeparately, and weigh accurately the button of ſilver it yields: or, at the ſame time when they eſſay ſilver, they put into a third cupel, in the muffle, a quantity of lead equal to that employed in both their eſſays; and when the operation is finiſhed, and the buttons are to be weighed, they throw the ſmall button produced from the lead alone into the ſcale which contains the weights; and as this exactly counterpoiſes the ſmall portion of ſilver which the eſſay buttons have received from the lead employed in the cupellation, the weights will ſhew preciſely the quantity of ſilver contained in the ingot, and thus the trouble of calculating is prevented. The ſmall button of ſilver procured from the cupellation of lead alone is called the *witneſs.* But to prevent this trouble, eſſayers generally employ lead which contains no ſilver, ſuch as that from Willach in Carinthia, which is therefore procured by eſſayers.

In the ſecond place we ſhall obſerve, that a certain quantity of ſilver always paſſes into the cupel, as refiners in the great have long obſerved, and which happens alſo in eſſaying ſmall quantities. The quantity of ſilver thus abſorbed, varies according to the quantity of the lead employed, and the matter and form of the cupels; all which objects will undoubtedly be determined by the above-mentioned chemiſts.

The cupellation which we have now deſcribed is exactly the ſame for eſſays, by which the produce of a ſilver ore, or of an ore of another metal containing ſilver, is determined. But as theſe ores contain frequently gold, and ſometimes in conſiderable quantity, when theſe eſſays are made, the buttons of ſilver obtained by the eſſays ought to be ſubjected to the operation called *parting*. *See* SILVER, REFINING, FURNACE (ESSAY), MUFFLE, *and* CUPEL.

CCLXXII. ESSAY *of the* VALUE *of* GOLD. The fictitious weights uſed to determine the purity of gold, and to eſſay this metal, are different from thoſe of ſilver. *See the preceding article.* A maſs of gold perfectly pure, or which contains no alloy, is ideally divided into 24 parts, called *carats*; this pure gold is therefore called gold of 24 carats. If the maſs or ingot contain $\frac{1}{24}$ part of its weight of alloy, the gold is then of 23 carats; and if it contains $\frac{2}{24}$ or $\frac{1}{12}$ of alloy, it is gold of 22 carats, &c. Hence we ſee that the carat of gold is only a relative and proportional weight, ſo that the real weight of the carat varies according to the total weight of the maſs of gold to be examined. If this maſs of gold weighs a mark, the real weight of the carat will be $\frac{1}{24}$ of eight ounces, which is equal to a mark. If the maſs weigh an ounce, the carat will be $\frac{1}{24}$ part of an ounce, or 24 grains. If it is only a penny-weight or 24 grains, the real weight of a carat will be one grain; and ſo on.

For greater accuracy, the carat of gold is divided into 32 parts, which are relative and proportional weights, as the carat itſelf is. Thus $\frac{1}{32}$ of a carat of gold is $\frac{1}{32}$ of $\frac{1}{24}$, or the $\frac{1}{768}$ of any maſs of gold; and the gold which contains an alloy equal to the $\frac{1}{768}$ part of the whole maſs is called gold of 23 carats and $\frac{31}{32}$; gold which contains $\frac{2}{768}$ of alloy is gold of 23 carats and $\frac{30}{32}$; and ſo on.

The real weight now generally uſed in the operation for determining the purity of gold, is ſix grains. This weight then repreſents 24 carats. The half of this weight, or three real grains, repreſents 12 carats. According to this progreſſion, we ſhall find that $\frac{1}{4}$ of a real grain repreſents one carat, and the $\frac{1}{128}$ parts of a grain repreſents the $\frac{1}{32}$ of a carat, or the $\frac{1}{768}$ part of a maſs of gold to be eſſayed.

As theſe weights are exceedingly ſmall, ſome eſſayers employ a weight of 12 grains, which muſt be very convenient.

When a maſs or ingot of gold is to be eſſayed, ſix grains are to be cut off, and exactly weighed: alſo 18 grains of fine ſilver are to be weighed. Theſe two metals are to be cupelled together with about ten times as much lead as the weight of the gold. This cupellation is conducted preciſely like that of the eſſay to determine the purity of ſilver, excepting that the heat muſt be raiſed a little more towards the end of the operation when the eſſay is going to brighten. Then the gold is freed from all alloy but ſilver. If the quantity of copper or other alloy deſtructible by cupellation be required to be known, the remaining button is accurately weighed. The diminution of weight from the ſum of the weights of the gold and of the ſilver determines the quantity of this alloy.

The button containing gold and ſilver is then to be flattened upon a poliſhed piece of ſteel, and care muſt be taken to anneal it from time to time, to prevent its ſplitting and cracking. By this method it is reduced to a thin plate, which is to be rolled up, in order to be parted by aqua fortis. *See the word* PARTING. The diminution found after the parting from the original weight of the gold eſſayed, ſhews the whole quantity of alloy contained in that gold.

The eſſay for determining the purity of gold is then made by two operations: the firſt, which is cupellation, deprives it of all its imperfect metals; and the ſecond, which is parting, ſeparates all the ſilver from it. By antimony alſo gold may be purified, which is a kind of dry parting. By this ſingle operation, all the imperfect metals, and ſilver with which gold is allayed, are ſeparated. *See* PURIFICATION *of* GOLD *by* ANTIMONY. *See alſo* GOLD, SILVER, REFINING, ESSAY *to* DETERMINE *the* PURITY *of* SILVER.

CCLXXIII. ESSENCES. Eſſential oils are ſometimes called *eſſences*. Thus we ſay, eſſence of cinnamon, of turpentine, &c. to denote the eſſential oils of theſe ſubſtances. *See* OILS (ESSENTIAL).

CCLXXIV. ETHER. Ether is a white, tranſparent liquor, of a peculiar and penetrating ſmell. Ether is very volatile: it may be entirely diſtilled without leaving any reſiduum, or ſuffering any decompoſition or alteration. It is more volatile and inflammable than rectified ſpirit of wine. Its flame reſembles the flame of ſpirit of wine; but it is ſenſibly much greater, whiter, and more luminous. It is alſo accompanied with a ſlight ſmoke or ſoot, which ſpirit of wine is not.

Ether does not mix with water, as ſpirit of wine does, in all proportions; but ten parts of water are required to diſſolve one part of ether. This liquor has alſo a power of acting upon all oily and fat ſubſtances.

From theſe eſſential properties ether appears to be a ſubſtance exactly intermediate betwixt ardent ſpirits and oils, as has been proved in the elements of chemiſtry. *See* SPIRIT (ARDENT), *and* OIL.

Ether has been but lately known by chemiſts. From certain paſſages indeed of ſome old chemical books, we may infer that ether was not entirely unknown to their authors; but they have not mentioned it diſtinctly, nor have they ſufficiently deſcribed its properties, or the manner of making it: wherefore no attention was given to it, till the curioſity of chemiſts was excited by a publication in the Philoſophical Tranſactions for the year 1730, by a German who calls himſelf Frobenius, (which however is ſuppoſed to be a feigned name) in which he relates the experiments he had made on that liquor, to which he firſt gave the name *ether*. Since that time, many chemiſts have made experiments on this matter. At firſt they made ether difficultly and in ſmall quantities, and at length abundantly and eaſily; particularly ſince Mr. Hellot communicated to ſeveral artiſts a proceſs which he received from a foreign chemiſt. This proceſs has been printed in the Encyclopedia, with conſent of Mr. Hellot.

Since that time, Mr. Beaumé has operated more than any other chemiſt on ether. He has publiſhed the details of his experiments and reſearches, not only upon ether, but upon all the other ſubſtances produced from a combination of ſpirit of wine with vitriolic acid. This forms the completeſt treatiſe on this ſubject which has hitherto been publiſhed.

Vitriolic acid is not the only acid from the mixture of which with ſpirit of wine ether may be produced. The nitrous, marine, and acetous acids have alſo been found capable of forming, with ſpirit of wine, liquors poſſeſſed of all the eſſential properties of ether; but differing from ether, properly ſo called, or vitriolic ether, by properties peculiar to each. We ſhall ſpeak ſucceſſively of theſe different ethers, beginning with the vitriolic, called ſimply *ether*, becauſe it is the chief one and the firſt diſcovered. The following proceſs for making this ether, which is the beſt hitherto publiſhed, is extracted from Mr. Beaumé's diſſertation.

Put two pounds of perfectly rectified ſpirit of wine into a glaſs retort, and pour upon it at once two pounds of well concentrated vitriolic acid.

This acid being much heavier than the ſpirit of wine, ſinks directly to the bottom, and does not mix with the ſpirit of wine. Shake the retort gently, and repeatedly, that the two liquors may mix. The mixture will boil, and become very hot. Vapors will iſſue from it with a loud hiſſing noiſe, and a ſweet penetrating ſmell. The mixture will then aſſume a yellow-reddiſh color. Place the retort in a ſand-bath, warmed by degrees to the ſame heat with itſelf. Lute to it a receiver, in the ſide of which is a ſmall hole, and diſtill the mixture by a heat ſufficiently intenſe to make it quickly boil and to keep it boiling. At firſt a very ſweet ſpirit of wine will paſs into the receiver, after which the ether will come, which may be diſtinguiſhed by ſtriæ formed on the upper part and neck of the retort. Continue the diſtillation with the ſame degree of fire, and from time to time unſtop the ſmall hole of the receiver, till you perceive, upon applying your noſe near this ſmall hole, a ſuffocating ſmell of volatile ſulphureous acid. Then the receiver ought to be unluted; and the contained liquor, which will be nearly eighteen ounces, muſt be quickly poured into a glaſs bottle, which ought to be well ſtopped. This liquor is a mixture of a very dephlegmated part of the ſpirit of wine, of a ſweet penetrating ſmell, which paſſes at firſt; of ether, which was formed during the diſtillation; of a little oil; and ſometimes alſo of a ſmall quantity of ſulphureous acid; both which ſubſtances paſs frequently with the laſt portions of the ether, particularly if the diſtillation has been too long continued. To ſeparate the ether from theſe other ſubſtances, put the whole mixture into a glaſs retort, with a little deliquiated fixed alkali, to abſorb and retain the ſulphureous acid, and diſtill very ſlowly in a ſand-bath, with a very gentle lamp heat, till you have made one half of the liquor paſs over. The liquor that riſes in this diſtillation, called alſo *rectification*, is ether. (*p*)

Before the Count de Lauraguais had diſcovered that ether was miſcible with water in a certain proportion, the cuſtom was to put the ether after this diſtillation into a phial with diſtilled water, and to ſhake together theſe two liquors. The ether roſe quickly to the ſurface, and floated on the water; from which it might be ſeparated by a funnel, as oil may from water, and obtained unmixed. But this is evidently bad management: for in the firſt

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(*p*) Mr. Beaumé ſays, that by diſtilling together ſix pounds of concentrated vitriolic acid with an equal quantity of highly rectified ſpirit of wine, about ſix ounces of aromatic ſpirit of wine will be firſt diſtilled, and then ſome ether. By continuing a heat ſufficient to make the liquor boil, white vapors of a volatile, ſulphureous ſmell, together with ſome ether, will riſe; and thus in 15 or 16 hours, about three pounds and a half of liquor will have paſſed into the receiver. If another receiver be adapted to the retort; by continuing the diſtillation, from ten to ſixteen ounces of volatile ſulphureous ſpirit place, the water thus mixed diſſolves about one tenth part of its weight of ether before it is ſaturated, a [illegible] which is loſt; and in the ſecond place, for the ſame reaſon that water diſſolves ſome ether, the ether alſo diſſolves a certain quantity of water, by which it is weakened, and its properties altered, as Mr. Beaumé has obſerved.

The production of ether is one of the moſt beautiful and inſtructive phenomena of chemiſtry. Spirit of wine, which is at once inflammable, and miſcible with water in all proportions, differs from any oil by containing a more conſiderable quantity of water, which enters its compoſition as a principle or conſtituent part. This being eſtabliſhed, if we deprive ſpirit of wine of part of that aqueous principle by which it differs from oils, it ought to aſſume the characters of oil, and to approach ſo much more to an oily nature, as it has been deprived of a greater quantity of the watery principle which conſtitutes it ſpirit of wine and by which it differs from oil. But this is preciſely what happens to it in the production of ether, and in the analyſis of the remaining mixture after the formation of ether.

Concentrated vitriolic acid having a power of attracting water ſtrongly, does, when mixed with ſpirit of wine, accordingly at firſt unite with the water which [illegible] ſpirit of wine may contain ſuperabundantly: and its action would not ex[illegible]ther, and it would not ſeparate the watery principle from the ſpirit of wine, if a heat were not applied ſufficient for diſtillation; for ether cannot be obtained from this mixture but by diſtillation. But when by the diſtilling heat the power of the vitriolic acid to attract water is encreaſed, that acid then becomes capable of ſeparating the watery principle of the ſpirit of wine and of uniting with it.

As this is done gradually, ſo the ſpirit of wine which riſes in diſtillation ought to be more and more changed by the action of the vitriolic acid.

will paſs over, and from two to four gros* of oil. By diſtilling the liquor in the firſt receiver, together with a ſmall quantity of oil of tartar, by a very gentle heat of a lamp furnace, about two pounds and four ounces of pure ether may be obtained; and afterward when a new receiver is adapted, and a ſtronger heat applied, from eight to ten ounces of aromatic liquor, which makes a good anodyne mineral liquor of Hoffman, will be diſtilled. The ether which is firſt diſtilled is the pureſt, and that which paſſes afterwards has a ſmell of the oil of wine, improperly called ſweet oil of vitriol, and of the volatile ſulphureous acid. To obtain the largeſt poſſible quantity of ether, and free from the other liquors which are diſtilled in this operation, are the chief objects of attention: and, conſidering how much more volatile ether is than any of the liquors which affect its purity, we have reaſon to believe, that a larger quantity, and a purer ether than is procured by the ordinary proceſs, might be obtained by uſing an apparatus for the diſtillation and rectification, ſo contrived, that vents of different heights from the retort or matraſs ſhall be given to the vapors of the different degrees of volatility, to each of which vents a receiver ſhall be adapted; ſo that none but the pureſt ether can be found in the receiver communicating with the higheſt vent, and the ether which happens to be mixed with the other liquors in the receivers communicating with the inferior vents may be again rectified with leſs heat, till the whole quantity of pure ether be thus collected.

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* A gros is equal to 72 grains.

This accordingly happens; and very diſtinctly. The firſt liquor which riſes in this diſtillation is a portion of ſpirit of wine, very volatile, penetrating, and dephlegmated; but which has not been deprived of its watery principle, and therefore retains the eſſential properties of ſpirit of wine.

The liquor which riſes next is ſpirit of wine, deprived of part of its watery principle by vitriolic acid. It conſequently is ſpirit of wine eſſentially altered, and approximated to the nature of oil, in proportion to the quantity of watery principle which it has loſt. This is ether, which differs from ſpirit of wine in being no longer miſcible with water in all proportions, and in emitting a whiter and more brilliant flame, accompanied with ſome fuliginous ſmoke.

Theſe properties by which ether differs from ſpirit of wine characterize ſo well its oily nature, that moſt chemiſts conſider this liquor as a very volatile oil. It ſeems, however, to be rather an intermediate ſubſtance betwixt oil and ſpirit of wine. The ſolubility of ether by water makes us chiefly conſider it in this light; for what oil, properly ſo called, can be diſſolved by water as ether can?

If the diſtillation of the mixture be continued after the ether has riſen, the vitriolic acid, ſtill continuing its action upon the ſpirit of wine already altered, takes at length from it all the watery principle by which it differs from a true oil, and hence ought to leave it in the ſtate of oil. Accordingly, after the ether has paſſed over in diſtillation, an oil riſes which wants none of the eſſential properties of true oil, as it is not miſcible with water, burns with a fuliginous ſmoke, leaves a reſinous coal, &c. This oil, thus created in ſome meaſure during the operation, is known by the name improperly given to it, of *Sweet Oil of Vitriol.*

From all this we might infer, that if ether ready prepared were mixed and diſtilled with concentrated vitriolic acid, it ought to be changed and transformed into ſweet oil of vitriol. Accordingly Mr. Beaumé obſerved, that this did happen in an experiment he made, an account of which is given in his Diſſertation on Ether.

When the ſweet oil of vitriol is diſtilling, the vitriolic acid acts alſo upon the phlogiſton of the remaining part of the ſpirit of wine, and unites with one
part of the inflammable principle. Hence we may ſee at the ſame time much
ſulphureous, volatile, ſuffoc But as the vitriolic
acid which forms it then becomes c it has taken
from the ſpirit of wine, this firſt ſ acid, although very quick and
penetrating, is very aqueous, and has not

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of this ſulphureous acid is raiſed, which
times alſo a little concrete ſulphur is ſu
wards the end of the diſtillation, a a fixed
ſuppoſe; for the ſame ſubſtances are
ture of any oil with concentrated vitriolic acid. See OIL.

From all that has been ſaid concerning the nature and properties of ether we may conclude, that this ſubſtance is nothing elſe than ſpirit of wine deprived by vitriolic acid of a part of its aqueous principle, and thereby approximated to the nature of oil. Some chemiſts believe that vitriolic acid is a conſtituent part of ether. This opinion, although it is not demonſtrated, is not however deſtitute of probability, and deſerves to be examined by experiments. For, on one ſide, a more copious and diſtinct acid is contained in all oils than in ſpirit of wine; and on the other ſide, the particular properties by which ethers formed by the nitrous, marine, and acetous acids differ from vitriolic ether, ſeem to be owing to adhering portions of the acids with which theſe ethers are prepared. This queſtion requires a particular examination.

Ether is not employed in the arts, although it appears capable of being uſefully employed in many caſes, and particularly in the ſolution of certain concrete oily matters for the preparation of varniſhes; but its high price prevents its introduction into the arts.

As ether is the moſt volatile and evaporable of all known liquors, and as in general liquors produce a degree of cold proportionable to the quickneſs of their evaporation, as Mr. Beaumé diſcovered, and ſeveral others have obſerved; therefore a very great degree of artificial cold may be produced by means of ether. Mr. Beaumé has ſunk the mercury of Reaumur's thermometer to 40 degrees below the freezing point, by applying linens ſoaked in ether to the ball containing the mercury; and he makes this fine experiment every year in his courſe of chemiſtry conjointly with Mr. Macquer. (q)

Ether, like all thin and volatile oily matters, has the property of taking gold from aqua regia; but as it is more ſubtle than any other of theſe matters, it produces this effect better. For this purpoſe, ether ought to be poured upon a ſolution of gold in aqua regia, and the two liquors mixed together by ſhaking the containing phial. When this mixture is left to reſt, the ether ſoon diſengages itſelf from the aqua regia, and floats on the ſurface of the acid liquor, which being deprived of its gold is rendered white, while the ether has now acquired a yellow color from the gold it contains. This is an expeditious method of making a tincture of gold, or potable gold. We ought to obſerve that the gold which thus paſſes into the ether ſtill retains a certain quantity of aqua regia.

Ether is employed in medicine. As a very thin and volatile inflammable matter, it acts powerfully on the nervous ſyſtem, like all the matters of this kind. Frederic Hoffman was one of the firſt who employed it as a ſedative and antiſpaſmodic. The famous mineral anodyne liquor of this phyſician is nothing elſe than ſpirit of wine, in which are diſſolved ſome ether and ſweet oil of vitriol. It owes all its medicinal virtues to the ether.

Since ether has become more common and better known, many phyſicians preſcribe it ſingly, in the doſe of ſeven or eight drops upon a bit of ſugar, which is to be eat or to be diſſolved in ſome proper liquor and drank. It is given in flatulent colics, obſtinate hiccups, convulſive, hyſterical affections, and other diſorders of this kind. It certainly produces frequently excellent effects; but, like all other antiſpaſmodic remedies, it ſometimes produces none.

(q) Mr. Amontons, in a Memoir of the Academy of Paris, (1699) and more particularly, M. Richman, in a Memoir of the Academy of Peterſburg, (1747) have obſerved that cold was produced by evaporating fluids. Dr. Cullen diſcovered, that the cold thus produced by evaporating fluids was conſiderably greater in vacuo than in air. See *Eſſays Phyſ. & Liter.* Edinburgh, vol. 2, 1756.

Several perſons have affirmed, that ether applied externally to the back of the neck, or to the temples, diſſipated inſtantaneouſly, and as it were by enchantment, head-achs and meagrims. I have tried it in all doſes upon myſelf for theſe diſorders, but without ſucceſs; but we cannot from thence infer that it may not have better effects upon other perſons. (r)

CCLXXV. ETHER (ACETOUS). Since the diſcovery of the ether deſcribed in the preceding article, chemiſts have endeavoured to obtain ſuch a liquor from ſpirit of wine by means of other acids; and accordingly they produced it firſt by means of the nitrous acid, then by the acetous, and laſtly, by the marine. We ſhall ſpeak ſucceſſively of theſe ſeveral ethers.

The diſcovery of the production of ether by the acetous acid was made by the Count de Lauraguais. This ether is made by mixing together equal parts of rectified ſpirit of wine, and concentrated acid of vinegar obtained by diſtilling cryſtals of copper, called the Spirit of Venus, or radical vinegar. This mixture is to be diſtilled in the manner directed for vitriolic ether, and a conſiderable quantity of a liquor is obtained, which is poſſeſſed of the eſſential qualities of ether, as deſcribed in the former article, but which has alſo ſome of the acidity and peculiar ſmell of radical vinegar.

When this ether is mixed with liquid fixed alkali, and again diſtilled, or rectified by a lamp heat, an acetous ether is obtained free from ſuperabundant acid, and much liker to true ether. It retains, however, the ſmell, not of the acid, but of the inflammable part of vinegar.

We obſerve, that by this proceſs a greater quantity of ether is obtained than by diſtillation with vitriolic acid, which ſhews that the acid of vinegar is eſſentially fitter to produce ether than the vitriolic acid. This difference muſt undoubtedly be attributed to the great quantity of ardent ſpirit, which is one of the principles of the acid of vinegar, and which perhaps already approaches the ſtate of ether. *See* VINEGAR (RADICAL).

As this diſcovery has been but lately made, the properties of the acetous ether, and the phenomena which its reſiduum may afford, have not yet been ſufficiently examined.

CCLXXVI. ETHER (MARINE). The diſcovery of the true proceſs for making ether by means of the marine acid, is the lateſt which has been made on this ſubject. The Marquis de Courtanvaux has communicated his proceſs to the Academy of Sciences.

The difficulty with which marine acid unites in general with inflammable ſubſtances has retarded the diſcovery of marine ether; for no ether can be obtained by treating the moſt concentrated marine acid with ſpirit of wine in the ordinary method, by which the other ethers are procured. Able artiſts, and particularly Mr. Rouelle and Mr. Beaumé, had attempted unſucceſsfully to procure ether by diſtilling ſmoking marine acid with ſpirit of wine. Mr. Beaumé, indeed, in his Diſſertation concerning Ether, had given a proceſs, by which he affirms that he had obtained a ſmall quantity of marine ether. This proceſs conſiſts in making the fumes of the marine acid and of the ſpirit of wine meet together in the ſame receiver. But the quantity of ether obtained by this method was very ſmall. The proceſs alſo is troubleſome, and even imperfect, as Mr. Beaumé himſelf declares. He would not have publiſhed it in that imperfect ſtate, but becauſe the poſſibility of the fact had been denied. What he ſays may be ſeen in his Diſſertation on Ether.

(r) Ether diſſolves all eſſential and expreſſed oils, animal empyroumatic oil, reſins, and almoſt entirely ambergriſe. It diſſolves difficultly petroleum and oil of amber. It precipitates regulus of antimony from aqua regia, and ſilver from nitrous acid. It takes ſpots of greaſe from ſilks without affecting their colors.

Others, and particularly German chemiſts, had attempted to employ for this purpoſe a marine acid which was united with a metallic ſubſtance, ſuch as the butter of antimony, and had obſerved the ſingular phenomena which happened in theſe mixtures. The Marquis de Courtanvaux has perfectly ſucceeded by employing the ſmoking ſpirit of Libavius, which is a highly concentrated marine acid, obtained from corroſive ſublimate by tin, and impregnated with a conſiderable quantity of this metal.

This ſmoking liquor, mixed with an equal part of ſpirit of wine, and diſtilled together, eaſily produces a conſiderable quantity of a liquor poſſeſſed of all the eſſential properties of ether, and which may be conſidered as a true marine ether. The tin contained in the ſpirit of Libavius is ſeparated and precipitated in form of a white powder. This ether, like the others, muſt be rectified to be obtained in its greateſt purity. Some reflections concerning its nature will be found at the end of the following article.

CCLXXVII. **ETHER (NITROUS).** This ether is obtained by mixing nitrous acid with ſpirit of wine, but with peculiar circumſtances.

In the writings of ancient chemiſts traces of the nitrous as well as of the other ethers may be found; but theſe traces are neither clear nor preciſe. The firſt perſon who publiſhed a ſatisfactory account of this liquor, and who ſhewed the true method of obtaining it, was Mr. Navier, a Phyſician, at Chalons-ſur-Marne, and Correſpondent of the Academy of Sciences. His proceſs, which he communicated to the Academy in 1742, is very ſimple, as it conſiſts only in mixing together ſpirit of wine and ſpirit of nitre in a bottle, which is to be exactly cloſed, and left at reſt, till the ether is formed and collected like an oil upon the ſurface of the liquor. This ether is made, as we ſee, without diſtillation.

Since Mr. Navier has publiſhed his diſcovery, other chemiſts have endeavored to improve the proceſs. A very good proceſs is publiſhed in the Encyclopedia, which is attributed to Mr. Rouelle. Mr. Beaumé alſo has publiſhed one in his Diſſertation on Ether, which is very accurate, and is the reſult of many trials and reſearches. Mr. Beaumé's proceſs is as follows.

Put ſix ounces of rectified ſpirit of wine into a bottle made of ſtrong and thick glaſs, large enough to contain a pound of water. Place this bottle in a bucket of freſh water, which will be ſtill better for the purpoſe if it has been rendered colder by throwing into it two or three pounds of ice, in ſmall bits. Pour upon the ſpirit of wine, at four or five times, four ounces of ſmoking ſpirit of nitre, ſo concentrated, that a phial, capable of containing an ounce only of water, ſhall be capable of containing an ounce and a half of this ſpirit of nitre; obſerving, during the whole time of pouring the ſpirit of nitre, that the ſpirit of wine be kept in a ſtate of perpetual rotation. As ſoon as the two liquors are mixed, ſtop the bottle quickly with a good cork, which muſt be driven firmly into the neck of the bottle, and covered and faſtened with a piece of leather doubled, and bound with packthread. Leave it at reſt in the cold water, which ought to be ſometimes renewed.

Two or three hours afterwards, the liquor loſes ſome of its tranſparency by the interpoſition of many ſmall drops of ether, which are diſengaged throughout the liquor. This ether gradually collects and floats upon the ſurface. Within twenty-four hours the mixture will have become clear; and the ether formed, which will be about two ounces, may be ſeparated. But as more ether will ſtill be produced, the method is to leave it ſeven or eight days before any of it be ſeparated. After this time no more ether is formed. Pierce then the cork with a pointed inſtrument; and a conſiderable quantity of air will eſcape with a hiſſing noiſe, which had diſengaged itſelf during the production of the ether, and which is compreſſed in the bottle. When the air has eſcaped, uncork the bottle, and pour quickly its contents into a glaſs funnel, that the ether may be ſeparated.

The ether will amount to about four ounces, and the reſiduum will weigh five ounces and a half; ſo that half an ounce ſhall have been loſt during the proceſs. This ether ought to be put into a well cloſed cryſtal-glaſs bottle.

Nitrous ether in this ſtate has a ſmell like that of the vitriolic ether, but ſomewhat ſtronger and leſs agreeable. It has a light citron color; and as ſoon as the bottle which contains it is uncorked, it bubbles and efferveſces. When the ſtopper is put in looſely into the neck of the bottle, it may be obſerved to riſe and fall alternately, which appearance is occaſioned by vapors eſcaping from the ether. The cauſe of theſe phenomena is a conſiderable quantity of air which remains interpoſed betwixt the parts of ether; for when all this air has been once diſengaged from the ether, theſe phenomena do not happen.

Nitrous ether is not, in this ſtate, pure; as it retains ſome of the acid employed, from which it may be purified by mixing it with ſome fixed alkali, and rectifying it with a lamp-heat. In this rectification, it ſuffers a loſs of nearly one half its quantity.

The properties of this rectified nitrous ether are, that it burns with a more luminous flame than the flame of vitriolic ether; that this flame is accompanied with a more ſenſible quantity of ſoot; that after the ether is burnt, a reſiduum of coal is perceptible; and, laſtly, that if it be evaporated on the ſurface of water in open air, it leaves upon the water ſome oil, as the vitriolic ether does, but in a little larger quantity. In other reſpects, but in theſe which ſhew that the nitrous ether is of a more oily nature than the vitriolic, theſe two ethers are perfectly ſimilar.

The activity and violence with which nitrous acid acts upon the ſpirit of wine is the moſt remarkable circumſtance of this operation. The action of nitrous acid is ſo much ſtronger than that of vitriolic acid upon ſpirit of wine, that equal parts of concentrated nitrous acid and ſpirit of wine cannot be mixed and contained: for notwithſtanding all the precautions that can be taken to moderate the action of theſe two liquors upon each other, they mix with ſo much violence when that proportion is uſed, that the mixture is inſtantly heated almoſt to inflammation, is reduced to vapors, and burſts the veſſels with a terrible exploſion.

In Mr. Beaumé's Diſſertation upon Ether, an account of the trials which he made upon this ſubject, and of the reſulting phenomena, may be ſeen.

In the ſecond place, when ſpirit of wine and nitrous acid are mixed in proper proportions, ether may be obtained without diſtillation; which is peculiar to this acid. The effects peculiar to the nitrous acid, in the preparation of ether, are cauſed by the action which this acid has, not only on the watery principle, but alſo on the inflammable principle of the ſpirit of wine. We have therefore reaſon to believe that nitrous acid converts ſpirit of wine into ether, not only by depriving it of its watery principle, but alſo by acting upon its inflammable principle with which it combines, or to which perhaps it joins its own inflammable principle. This is ſo true, that nitrous ether may be made with a nitrous acid which does not ſmoke, and which is, in ſome meaſure, ſaturated with water. For this purpoſe, a larger proportion of ſpirit of wine ought to be added. But if nitrous acid converted ſpirit of wine into ether, merely by depriving it of its watery principle, a diluted acid ought not to have the ſame effect as a ſmoking and concentrated acid, particularly as it cannot concentrate itſelf during the operation, ſince this is performed without diſtillation. Beſides, as nitrous acid has a greater affinity than any other with the inflammable principle, and contains a greater quantity of it, we ought not to be ſurprized that nitrous ether is produced without diſtillation, and more eaſily than any other.

Marine acid, on the contrary, having the leaſt diſpoſition of all the acids to unite with the inflammable principle, and ſeeming to contain leſs of it than any other acid, does therefore produce ether with moſt difficulty; or, properly ſpeaking, does not produce any ether, when pure, but only when it has been combined with metallic ſubſtances, as tin and antimony; part of the phlogiſton of which it may have acquired. *See* Ether (Marine). It probably becomes more proper to combine with the inflammable principle of the ſpirit of wine, or to communicate that which it has received, after it has already begun to unite itſelf with the inflammable principle of metallic matters.

From theſe conſiderations we are inclined to believe, that in the production of ether, the acids act at the ſame time upon the watery and inflammable principles of the ſpirit of wine, by depriving this ſpirit of the former, and by combining partly with the latter; or by encreaſing its proportion of acid, and thereby approximating it to an oily nature.

All acids, and particularly mineral acids, ſuffer ſingular alterations, and even tranſmutations, when they are diſtilled to dryneſs with a ſufficient quantity of ſpirit of wine. Mr. Pott, in his Diſſertation on the Vinous Acid of Nitre, ſays, that this acid by being combined with ſpirit of wine loſes the diſagreeable ſmell peculiar to it, and acquires a penetrating and agreeable ſmell; that it does not riſe in form of red vapors; but that it riſes with a leſs degree of heat than when pure, and that it acts leſs powerfully on fixed alkalis and abſorbent earths. He adds, that by diſtilling this mixture, oil and a reſiduous coal may be obtained; and that if nitrous acid previouſly combined with ſpirit of wine be ſaturated with a fixed alkali, a ſalt is formed which does not detonate like nitre, but burns like an oily ſalt, without waſte or diminution.

Pott reaſonably thinks, that this experiment may ſuggeſt hints concerning the tranſmutation of acids, and he believes that the nitrous acid in that experiment loſes its detonating and other eſſential qualities; becauſe the phlogiſton which enters its compoſition as a principle is joined and confounded with the inflammable matter of the ſpirit of wine. The marine acid ſeems to ſuffer leſs alteration in combining with ſpirit of wine; for Mr. Pott ſays alſo, in his Diſſertation on the Vinous Acid of Salt, that having ſaturated with an alkali ſome marine acid previouſly treated with ſpirit of wine, he obtained a regenerated common ſalt, which poſſeſſed all the eſſential properties of common ſalt. Nevertheleſs, Mr. Pott, having diſtilled to dryneſs the thick matter which remains after the moſt fluid and volatile part had been diſtilled from a mixture of marine acid and ſpirit of wine, obtained a reſiduous black fixed coal; which proves that one part of the acid of ſalt contracts in this experiment a very intimate union with the principles of ſpirit of wine; for the marine acid and ſpirit of wine diſtilled ſingly do certainly not leave any reſiduum.

CCLXXVIII. ETHIOPS (MARTIAL). Martial ethiops is iron divided into exceedingly fine parts by the action of water.

This preparation was introduced into medicine by the younger Lemeri, who called it *ethiops* from its black color. To make ethiops, filings of iron are taken, very clean and free from ruſt, and are put into a glaſs veſſel; on theſe pure water is to be poured, to the height of three or four fingers thickneſs above the filings; the filings are to be frequently ſtirred with a ſpatula, till they become ſo fine a powder, that when agitated they remain long ſuſpended in the water: the water thus rendered turbid by the ſuſpended powder of iron, is to be decanted; and the ſediment which is depoſited is to be dried and ground on a porphyry. This is the martial ethiops.

Iron is a metal which is ſoluble in many menſtruums. Its ſurface is ſenſibly affected by the combined action of air and water, and is in ſome meaſure corroded. It is thereby deprived of part of its inflammable principle, and partly reduced to an earth or calx, called *ruſt*: but to produce this effect, theſe two elements muſt concur; for iron is not ruſted nor altered by expoſure to dry air, or to water alone, without contact of air. (*s*)

Nevertheleſs, the operation of ethiops martial ſhows that water alone, without the concurrence of air, is capable of a certain action upon iron; ſince this metal is by this action, continued ſome time, reduced to parts exceedingly ſmall. Whether this effect is cauſed by ſome heterogeneous particles in the water or in the iron, has not yet been determined. The iron thus reduced into martial ethiops is certainly very different from ruſt. It is black, attractable by magnets, and ſoluble in all acids; which proves that it is not deprived of its inflammable principle. Ruſt, on the contrary, has none of theſe qualities.

Theſe properties of martial ethiops have induced ſome perſons to propoſe it as a remedy much ſuperior to other preparations of iron. This manner of preparing iron for medicinal purpoſes is certainly good and unexceptionable; but

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(*s*) Iron is not ſo readily ruſted when kept immerſed in water, as when it is firſt moiſtened and then expoſed to air; but it is nevertheleſs ſubject to ruſt if it be kept a few days under water, as thoſe workmen know who have occaſion frequently to keep pieces of iron under water, to ſoften and render the metal more ductile, and alſo to preſerve the ſurface from ruſt during a ſhort time. When they have occaſion to preſerve iron from ruſt a longer time, they immerſe it in lime-water.

Mr. Lemeri certainly ought not to have declaimed againſt all other preparations of iron indiſcriminately, nor to have adviſed their total diſuſe in medicine. He pronounced this general proſcription without ſufficiently underſtanding the matter. He would probably have been more indulgent, if he had known that ſeveral martial ſaffrons, ſuch as thoſe called aperitive, and which are nothing but ruſt, are capable of eaſily reſuming, and by the humid way all the phlogiſton which is neceſſary to reſtore to them all the properties of martial ethiops; and that this change is actually produced upon them when they are taken internally, by the fat matters which they meet in the ſtomach, in the inteſtines, and in the aliments and digeſtive juices. This is proved by the blackneſs of the excrements of thoſe who have taken theſe martial ſaffrons.

Mr. Lemeri had certainly not examined the nature of the precipitates obtained from ſolutions of iron in acids, and particularly in the vitriolic and marine acids, by a phlogiſticated alkali; for he muſt have obſerved that ſuch precipitates receive from the alkali a ſufficient quantity of phlogiſton, to give it a dark and blackiſh color, and to render it ſoluble in any acid: conſequently theſe precipitates, which are at leaſt as fine as the martial ethiops, are alſo equal to it in ſolubility, and preferable from the greater facility of their preparation.

When well phlogiſticated precipitates are required, they ought to be dried in cloſe veſſels, and by diſtillation. This is an operation which is alſo neceſſary for martial ethiops, although the author does not direct it; for the iron, being moiſt and much divided, ruſts with the greateſt facility from the contact of air.

Martial ethiops, and the martial precipitates and ſaffrons above-mentioned, are ſucceſsfully employed in medicine as excellent tonic and fortifying remedies. *See upon this ſubject* IRON.

CCLXXIX. ETHIOPS MINERAL. Ethiops mineral is a combination of mercury with a ſufficiently large quantity of ſulphur. The color of this compound is black, and hence it has been named ethiops.

Ethiops mineral may be made either by fuſion, or by trituration without fuſion.

To make ethiops mineral by fuſion: To ſulphur melted in an unvarniſhed earthen veſſel, an equal quantity of very pure mercury is to be added; the veſſel is at the ſame time to be taken from the fire, and the mixture is to be ſtirred with a ſpatula till it be cold and fixed; the mixture is then become a black and friable maſs, which is to be pounded and ſifted. This is ethiops.

To make this preparation without fire, two parts of mercury are triturated in a glaſs or marble mortar with three parts of flowers of ſulphur, till the mercury no longer appears.

Mercury and ſulphur have a ſtrong diſpoſition to unite together. For this purpoſe, their integrant parts muſt be made to touch, and then they contract an adheſion, but not ſo ſtrong as that which they acquire by ſublimation in the proceſs for making cinnabar.

The black color of ethiops is always taken by mercury, when it is much divided and mixed with inflammable matters. In this reſpect it reſembles ſilver, lead, and other metals, which acquire a black color from the ſuperficial union which they contract with ſulphur or other phlogiſtic matters.

Although the union of mercury with ſulphur in ethiops is not ſo ſtrong as in cinnabar, we muſt not believe that in ethiops theſe two ſubſtances are not united, but only mixed and interpoſed; for they really adhere and are combined together. The proof of this is, that they cannot be ſeparated from each other without intermediate ſubſtances. Theſe ſubſtances are the ſame as thoſe which are capable of procuring a ſimilar ſeparation by decompoſing cinnabar. *See* CINNABAR.

The difference betwixt ethiops prepared by fuſion and ethiops prepared by trituration is, that the former contains a leſs quantity of ſulphur than the latter.

Mr. Lemeri has obſerved, in his Courſe of Chemiſtry, that when ethiops is made with fire, one half of the ſubſtances employed is loſt; but the proportion in which each of the ſubſtances is diſſipated is not known: we are, however, certain that more ſulphur is loſt than mercury; notwithſtanding which, each kind of ethiops contains more ſulphur than is neceſſary for the ſaturation of the mercury, as evidently appears from the operation of making artificial cinnabar.

The chief uſe of ethiops mineral is in medicine. It may be given from ſix grains to half a dram, incorporated with other ſuitable remedies. It is employed as a reſolvent in the aſthma, ſcrophula, obſtructions and diſeaſes proceeding from a ſtoppage or thickneſs of humors. Some phyſicians preſcribe it in venereal diſeaſes: others affirm, that ethiops has no medicinal virtue; however, it certainly occaſions ſalivation ſometimes, although ſeldom. *See* MERCURY.

CCLXXX. EVAPORATION. Evaporation is a chemical operation, by which, with a certain degree of heat and acceſs of air, volatile ſubſtances are ſeparated from others leſs volatile.

The effect of evaporation is eſſentially the ſame as that of diſtillation, with this difference, that diſtillation is almoſt always employed to ſeparate and collect a volatile ſubſtance; whereas evaporation is always employed to ſeparate and collect the fixed or leſs volatile ſubſtance only, the more volatile part being neceſſarily loſt in the operation.

Evaporation is always made in open air, and with open veſſels; for air contributes much to the volatiliſation of bodies, and evaporation is only performed from their ſurfaces: hence the general rules for evaporation are, to place the body from which volatile parts are to be evaporated in a flat, ſhallow, wide veſſel, ſo that it ſhall preſent to the air a large ſurface, towards which even a current of air ought to be directed.

In all evaporations the degree of heat ought to be proportioned to the volatility of the ſubſtance to be evaporated, and ſtill more to the degree of fixity of the ſubſtance intended to be left, and of its adheſion to the volatile parts. Thus, the leſs fixed the remaining ſubſtance is, and the more ſtrongly it adheres to the volatile ſubſtance, the leſs the heat ought to be. For inſtance, if we would obtain the portion of oil which is found in rectified ſpirit of wine and ether, theſe liquors ought to be evaporated, as Mr. Baumé did, upon the ſurface of water in open air, and without any other heat than that of the atmoſphere; for, however little the evaporation of theſe liquors is urged by a heat ſomewhat too ſtrong, the volatility of this ſmall portion of oil differs ſo little from that of ſpirit of wine and of ether, that it would entirely exhale with theſe liquors without any ſeparation, as it does when they are rectified. Thus Mr. Duhamel having diſcovered, by his experiments, that the volatile alkali of ſal ammoniac carries off with it a conſiderable portion of the fixed earthy intermediate ſubſtances employed to diſengage it, could not afterwards ſeparate this earthy part from the concrete volatile alkali, but by allowing this latter to diſſipate itſelf by the heat alone of the air, and by an evaporation which continued ſeveral months; becauſe this earthy part, although very fixed, is ſo well combined, and adheres ſo ſtrongly to volatile alkali, that it is always carried along with the ſalt in evaporation, whenever the heat exceeds that of the atmoſphere. *See Mr. Duhamel's Memoirs concerning Sal Ammoniac amongſt the Memoirs of the Academy.*

On the contrary, in ſome caſes evaporation may be urged by a ſtrong heat, and even by a current of air directed upon the ſurface of the body. This is practiſed when the part to be evaporated is not very volatile, and requires conſiderable heat to raiſe it, and when the remaining ſubſtance is very fixed, and does not adhere much to the volatile part. Such, for example, is the evaporation of regulus of antimony in the *purification of gold by antimony.* See *that operation.*

The veſſels employed in evaporation are baſons, teſts, crucibles; and theſe veſſels are made of glaſs, metal, or of earth, according to the nature of the bodies on which the operation is to be performed.

CCLXXXI. EUPHORBIUM (a).

CCLXXXII. EXCREMENTS (LIQUID) *of* ANIMALS.

See URINE.

CCLXXXIII. EXCREMENTS (SOLID) *of* ANIMALS.

Alchemiſts who have ſought every where for their great work, as they called it, have particularly operated much on the excrements of men and other animals; but philoſophical chemiſtry has acquired no knowledge from all theſe alchemical labors, from the obſcurity with which their authors have deſcribed them. The philoſophic chemiſts have not much examined animal excrements. Of theſe, Homberg is the only one who has particularly analyſed and examined human ordure; and this was done to ſatisfy an alchemical project of one of his friends, who pretended that from this matter a white oil could be obtained, without ſmell, and capable of fixing mercury into ſilver. The oil was found by Homberg, but mercury was not fixed by it.

The labors of this able chemiſt were not however uſeleſs, like thoſe of the alchemiſts, becauſe he has clearly related the experiments he made on this matter, in the Memoirs of the Academy of Sciences. Theſe experiments are curious, and teach ſeveral eſſential things concerning the nature of excrements. The reſult of theſe experiments is as follows.

Freſh human fæces, being diſtilled to dryneſs in a water bath, furniſh a clear, watery, inſipid liquor, of a diſagreeable ſmell, but which contains no volatile alkali; which is a proof that this matter, although nearly in a putrefactive ſtate, is not however putrefied; for all ſubſtances really putrid furniſh with this degree of heat a manifeſt volatile alkali. *See* PUTREFACTION.

(a) EUPHORBIUM is a very acrid, gummy, reſinous juice. From an ounce of euphorbium five drams were extracted by ſpirit, and from another ounce five drams alſo were extracted by water. Both theſe extracts, but chiefly the ſpirituous, were acrid and corroſive. *Neuman.*

The dry reſiduum of the foregoing experiment, being diſtilled in a retort with a graduated fire furniſhes volatile alkaline ſpirit and ſalt, a fetid oil, and leaves a reſiduous coal. Theſe are the ſame ſubſtances which are obtained from all animal matters. *See* SUBSTANCES (ANIMAL).

Human fœces, diluted and lixiviated in water, furniſh by filtration and evaporation of the water an oily ſalt of nitrous nature, which deflagrates like nitre upon ardent coals, and which inflames in cloſe veſſels, when heated to a certain degree.

This ſame matter yielded to Homberg, who treated it by a compleat fermentation or putrefaction, excited by a digeſtion during forty days in a gentle water-bath heat, and who afterwards diſtilled it, an oil without color, and without bad ſmell, and ſuch as he endeavored to find; but which did not, as we ſaid before, fix mercury into ſilver.

CCLXXXIV. EXPRESSION. Expreſſion is a mechanical operation, by which the juices of many plants are obtained; and ſweet oils, which are not volatile, may be extracted from many ſubſtances in which they reſide ſuperabundantly and uncombined. Such are all emulſive ſeeds, and ſome fruits, as oranges, citrons, lemons, olives, &c. An oil may alſo be obtained from yolks of eggs by expreſſion.

This operation is performed by putting the ſubſtance to be expreſſed, previouſly bruiſed, in a machine called a preſs.

The plants from which the juices are to be extracted, having been bruiſed in a mortar, ought to be wrapped up in a ſtrong and cloſely woven linen cloth, and then put into the preſs. The plants which are not very ſucculent, or too mucilaginous to give their juices by expreſſion, ought to be mixed with ſome water when they are bruiſed in a mortar.

Grains or ſeeds muſt alſo be bruiſed before they are expreſſed to obtain their oil, ſo as to form them into a greaſy paſte, the oil of which exſudes ſpontaneouſly. They are then to be wrapped in a ſtrong linen cloth, and expreſſed. To obtain as much oil as is poſſible, this paſte ought to be expreſſed betwixt two hot iron plates. But this method renders oils rancid, and therefore ought not to be uſed in the preparation of oils for medicinal purpoſes.

To obtain oil from yolks of eggs by expreſſion, they ought previouſly to be hardened by baking, or even a ſlight torrefaction. *See* JUICES (EXPRESSED), *and* OILS (SWEET).

CCLXXXV. EXTRACT. This word, taken in the moſt general ſenſe of which it is capable, is applicable to ſubſtances ſeparated from any compound body by a proper menſtruum. But it is generally confined to denote ſubſtances ſeparated from vegetables by water.

To make an extract from any vegetable ſubſtance, it muſt be infuſed or boiled in a ſufficient quantity of water, to extract from it all the ſubſtances ſoluble in this menſtruum. If the vegetable matter of which the extract is to be made is itſelf ſucculent and watery, it need not then be infuſed or boiled. The juice which contains all the matter of the extract may be expreſſed; for in this caſe, the water in the plant has the ſame effect as the water employed in infuſion or decoction.

Then the infuſion, decoction, or expreſſed juice of the plant muſt be evaporated till they acquire more or leſs firm conſiſtence. For ſome extracts are made as ſoft as paſte, and are called *ſoft extracts*; others are evaporated till they become dry, and are called *dry* or *ſolid extracts*.

The liquor from which the extract is to be made by evaporation is always more or leſs charged with feculent matters, earthy or reſinous, which render it turbid, becauſe theſe matters are not ſoluble in water. Theſe matters are generally ſeparated before the liquor is evaporated to the conſiſtence of an extract, which may be done by clarification with the white of an egg, or otherwiſe. By this ſeparation of feculent matter, ſoft extracts are rendered leſs liable to ferment and to become mouldy. But as the intention of making an extract is to preſerve all that can be preſerved of the principles of plants, the liquor of the extract ought not to be clarified, but it ought to be evaporated till it becomes dry, and thereby rendered not ſubject to change.

As extracts ought to reſemble, as nearly as is poſſible, the vegetables from which they are obtained, they ought to be evaporated with a gentle heat, and in a water-bath; becauſe the delicate and compounded principles of vegetables are liable to be changed by a ſtrong heat. But to avoid the inconveniencies attending a tedious evaporation, by which a fermentation of the matter might be induced, this evaporation may be accelerated by encreaſing the ſurface of the liquor, which therefore ought to be diſtributed in many flat and wide-mouthed veſſels. *See* EVAPORATION. In this manner the Count de la Garaye prepared what he called *eſſential ſalts*, which are nothing but ſolid extracts, the beſt and moſt perfect which can be obtained.

From what has been ſaid concerning extracts, we may conclude, that they are collections of the proximate principles of vegetables, and chiefly of thoſe which are ſoluble in water, and which are not ſo volatile as to be capable of diſſipation by the heat of boiling water. They contain, therefore, when well made, all the gummy, mucilaginous, ſaponaceous, (that is, the oil rendered ſoluble in water by ſome ſaline ſubſtance) bitter, or ſaccharine matters; and laſtly, all the eſſential ſalts, acid or others, or any other ſaline matters, which are contained in vegetables. In well-made extracts are alſo found portions of the oily, reſinous, and earthy principles of vegetables, which, although inſoluble in water, have been extracted along with the other principles into the juice, infuſion, or decoction; excepting, for particular reaſons, theſe principles are required to be excluded. If extracts are required which ſhall poſſeſs as much as they can of the properties and virtues of plants, we ought not only to extract by water but alſo by ſpirit of wine, and to mix together the ſubſtances thus extracted by theſe two menſtruums. *See* ANALYSIS *by* MENSTRUUMS.

The taſte of almoſt all extracts is bitter or ſaline, and ſomewhat like that which ſugar or other vegetable ſubſtances acquire by ſlight burning. But this latter quality is faulty. It proceeds from a too ſtrong heat having been employed to evaporate the extracts; by which ſome of the ſubſtances contained in the extract are conſiderably changed or even deſtroyed.

Several dry extracts, or eſſential ſalts of the Count de la Garaye, attract moiſture from the air, and even become liquid. This property is occaſioned by a ſeparation of the ſaline from the reſinous and earthy parts of the vegetable, and which are therefore uncombined, and conſequently apt to attract moiſture.

Theſe extracts ought to be preſerved in well cloſed bottles.

CCLXXXVI. EXTRACT (MARTIAL). This name is given to a pharmaceutical preparation, which is not, properly ſpeaking, an extract, ſince it is only a combination of iron with tartar, called *Tincture of Mars*, reduced to the conſiſtence of an extract. *See* TINCTURE *of* MARS.

F.

CCLXXXVII. **FALSE GALENA.** This is a mineral which reſembles at firſt view the lead ore called galena; but from which no metal is extracted. (u)

CCLXXXVIII. **FALSE PRECIPITATE.** This name is given to a matter which has the appearance of a precipitate, but which has not been ſeparated from a menſtruum. Such is mercury reduced into a red powder without addition, and merely by heat, improperly called *precipitate per ſe*, or mercury precipitated by itſelf: ſuch alſo is *red precipitate*, which is mercury diſſolved in ſpirit of nitre, and afterwards deprived of moſt of the acid by fire, without any intermediate ſubſtance. Silver, lead, mercury, ſeparated from nitrous acid by marine or vitriolic acids or ſalts, are alſo generally conſidered as precipitates, and are really ſo, as they are actually ſeparated from one ſubſtance by the intervention of another: but as this ſeparation is made by the union of the precipitated metal with the precipitating acid, ſuch precipitate ought to be diſtinguiſhed from thoſe which are nothing but the precipitated matter uncombined and ſingle. *See* PRECIPITATES *and* PRECIPITATION.

CCLXXXIX. **FAT.** Fat is an oily concrete ſubſtance, depoſited in different parts of animal bodies.

To obtain fat very pure, it muſt be cut into pieces, and cleaned from the interpoſed membranes and veſſels; it muſt then be cleanſed from its gelatinous matter by waſhing with water, till the water comes from it colorleſs and inſipid; it is afterwards to be melted with a moderate heat, in a proper veſſel, with a little water; and it is to be kept thus melted till the water be entirely evaporated, which is known by the diſcontinuance of the boiling, which is cauſed by the water only, and which laſts till not a drop of it remains: it is afterwards to be put into an earthen pan, where it fixes; then it is exceedingly white, ſufficiently pure for the purpoſes of pharmacy or chemical examination.

(u) FALSE GALENA, *Pſeudo Galena*, called alſo *Black-jack*, or *Blend*, is an ore of zinc, containing, beſides that ſemimetal, generally ſome iron, together with the mineralizing ſubſtances ſulphur and arſenic. It is frequently intermixed with the lead ore called galena, and ſometimes with the cupreous pyrites. In England the former kind is found in the lead mines of Derbyſhire, and the latter in the copper mines of Cornwall. This mineral, formerly neglected as uſeleſs, has lately been employed, after a careful calcination, inſtead of calamine, for the manufacture of braſs, and might alſo be employed as calamine is, for the extraction of zinc. For theſe purpoſes, that kind of blend is fitteſt which contains moſt zinc, and leaſt of iron and arſenic. Such is the blend of Derbyſhire, which is a very rich ore of zinc. This kind is more laminated in its texture, and of a greyiſh color when ſcratched; whereas the blend found in Cornwall has a more teſſelated texture, conſiſting of oblong parallelipipedons, is of a reddiſh color when ſcratched, and contains a larger quantity of iron and arſenic.

Fat thus purified has very little taſte, and a weak, but peculiar ſmell.

Mineral acids exhibit the ſame phenomena with fat, as they do with the fixed ſweet oils of vegetables, which contain nothing gummy or reſinous, and which do not dry. Such is the oil of ben, oil of olives, and all thoſe which chemiſts call *fat oils.*

Alkalis diſſolve fat, as they do theſe oils, and form a ſimilar ſoap. Fat contains no principle ſo volatile as to be raiſed with the heat of boiling water. It does not inflame but when heated in open air ſo as to riſe in vapors. Laſtly, by age it contracts an acrid and rancid quality.

When fat is diſtilled with a heat ſuperior to that of boiling water, which muſt therefore be done in a retort, and in a naked fire, firſt an acid phlegm ariſes, and a ſmall portion of oil which remains fluid. As the diſtillation continues, the acid becomes ſtronger, and the oil thicker, and at laſt it congeals in the receiver. No other principle ariſes during this diſtillation: and laſtly, when the retort is red, nothing remains but a very ſmall quantity of that kind of coal which cannot be burnt without very great difficulty. *See* COAL.

If the congealed oil which is found in the receiver be again diſtilled, more acid is obtained, and an oil which does not congeal; and thus by repeating the diſtillations the oil is more and more attenuated. While it is thus deprived of its acid, it acquires a more and more penetrating ſmell; and thus by diſtillation alone it may be rendered as volatile as eſſential oils, and capable of riſing with the heat of boiling water.

From all theſe properties of fat we may perceive it is a ſweet concrete oil, not volatile, and perfectly analogous to butter and wax; and that its conſiſtence, as well as the conſiſtence of theſe analogous ſubſtances, is cauſed by an acid intimately united with it, which cannot be ſeparated but gradually and by repeated diſtillations. Fat, and all other analogous oily matters, cannot be heated ſufficiently to be raiſed into vapors, without ſuffering a conſiderable alteration, and even decompoſition. The vapors which riſe from it, when heated in open air, are the ſame as thoſe which riſe when diſtilled in cloſe veſſels. They conſiſt of acid and attenuated oil. This acid is remarkably penetrating, acrid, and volatile; it irritates and inflames the eyes, the throat, and lungs; it makes the eyes ſhed tears, and excites a cough as much as volatile ſulphureous acid does, although its nature be very different.

When fat is in its natural ſtate, and has not yet ſuffered any alteration, its acid is ſo well combined with its oily part, that none of its properties can be perceived. Thus fat, in good condition, is very mild, and uſed ſucceſsfully in medicine, particularly externally, for its lenient quality; but, notwithſtanding its great mildneſs, before it has been heated ſufficiently to decompoſe it, and while it is yet freſh, it becomes exceedingly acrid, irritating, and cauſtic, when its acid is partly diſengaged by fire or by time.

When fat is become very rancid, not only its medicinal effects, but alſo many of its eſſential properties, are totally changed, particularly its property of reſiſting the action of ſpirit of wine: for this menſtruum, which does not affect pure and unchanged fat, diſſolves ſome portion of fat which has been ſtrongly heated, or which has become rancid. This effect can certainly proceed from no other cauſe, than that the acid of the fat diſengages itſelf in both theſe caſes. Mr. Macquer has ſhewn this in his Memoir concerning the Cauſe of the different Solubility of Oils in Spirit of Wine. We ſhall ſpeak more fully on this matter at the article OIL. Mr De Machy, an intelligent apothecary of Paris, and an able chemiſt and obſerver, has made a remark upon this ſubject which correſponds with this opinion; which is, that all the rancidity of fat may be taken from it by treating it with ſpirit of wine. Now, this evidently happens, becauſe the ſpirit of wine diſſolves all the portion of fat which is diſengaged from its acid; that is, all the rancid part, while it does not touch that which is not changed. This practice may be advantageouſly employed for the preſervation or recovery of ſome fats uſed in medicine, but which are rare, and not to be procured in their recent ſtate.

The decompoſition of fat, from which may be obtained acid, oil, a very ſmall quantity of reſiduous coal, and not a particle of volatile alkali, proves evidently, that this ſubſtance, although elaborated in animal bodies, of which it makes a part, has not the marks of an animaliſed matter; it therefore ſeems to make a ſeparate claſs, and to be produced from the oily parts of the aliments which could not enter into the compoſition of the nutritive juices: it is conſequently an oil ſuperabundant to nutrition, which nature depoſites and reſerves for particular purpoſes. One of the chief uſes of fat probably is to receive into its compoſition, to blunt and correct a great part of the acids of the aliments, and which are more than are requiſite to the compoſition of the nutritive juice, or which nature could not otherwiſe expel. This is certain, that the greater the quantity of aliments is taken by healthy animals above what is neceſſary for their nouriſhment and reproduction, the fatter they become. Hence animals which are caſtrated, which are not much exerciſed, or which are come to an age when the loſs and production of the ſeminal fluid is leſs; and which, at the ſame time, conſume much ſucculent aliment, generally become fatter, and ſometimes exceedingly ſo.

Although fat be very different from truly animaliſed ſubſtances, and appears not eaſily convertible into nutritive juices, it being generally difficult of digeſtion, and apt to become rancid, as butter does in the ſtomachs of many perſons; yet in certain caſes it ſerves to the nouriſhment and reparation of the body. Animals certainly become lean, and live upon their fat, when they have too little food, and when they have diſeaſes which prevent digeſtion and production of the nutritive juice; and in theſe caſes the fatter animals hold out longer than the leaner. The fat appears to be then abſorbed by the veſſels deſigned for this uſe, and to be transformed into nutritive juice.

The fats of different animals differ little. They have all the ſame eſſential properties, and only vary ſenſibly in conſiſtence. Frugivorous animals, and particularly ſheep, have very firm fat; moſt reptiles, and particularly fiſh, which are almoſt all carnivorous, have a ſoft and ſometimes a liquid fat. *See* BUTTER, WAX, *and* OIL.

CCXC. FEATHERS. (*x*)

CCXCI. FENNEL. (*y*)

CCXCII. FENUGREEK. (*z*)

CCXCIII. FERMENT. A ferment is a ſubſtance actually fermenting, or ſtrongly diſpoſed to ferment, and which is employed to determine and excite another body to fermentation; ſuch are yeaſt, leaven, and other ſuch ſubſtances. *See* FERMENTATION.

CCXCIV. FERMENTATION. Fermentation is an inteſtine motion, excited ſpontaneouſly, with the aſſiſtance of proper heat and fluidity, betwixt the integrant and conſtituent parts of certain very compound bodies, from which reſult new combinations of the principles of theſe bodies.

All vegetable and animal matters, into the compoſition of which enter a certain quantity of fluid oil and earth, rendered perfectly ſoluble in water by the intervention of a ſaline matter, being diffuſed in a ſufficient quantity of water to become liquid, or at leaſt ſoft, and being expoſed to heat from a few degrees above the freezing point to twenty-five and more, and when the communication with air is not entirely ſtopt, ſuffer ſpontaneouſly the fermentative motion, which entirely changes the nature and proportion of their principles.

But this fermentation, and the new compounds produced by it, differ conſiderably both in properties and proportions, according to the nature of the fermented ſubſtance, and the circumſtances of the fermentation.

We may diſtinguiſh three particular kinds of fermentation, or three degrees of the ſame fermentation, which refer to the three principal products which reſult from it.

The firſt is called *vinous* or *ſpirituous fermentation*; becauſe it changes into wine the liquors which undergo it, and becauſe from this wine may be obtained an inflammable ſpirit, miſcible with water, called *ſpirit of wine*.

The ſecond kind of fermentation is called *acid* or *acetous*, becauſe the product of it is an acid, or *vinegar*.

The third fermentation is called the *putrid* or *putrefaction*. It might alſo be called the *alkaline* fermentation, becauſe much alkali is diſengaged by it.

All matters ſuſceptible of the ſpirituous fermentation may afterwards undergo the acid, and, laſtly, the putrid fermentation; but ſome ſubſtances are not ſuſceptible of the ſpirituous fermentation, but proceed firſt to the acid, and afterwards to the alkaline or putrid fermentation; and laſtly, ſome ſubſtances are ſuſceptible of the putrid fermentation only. Further, a ſubſtance which

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(*x*) FEATHERS. From ſixteen ounces of feathers Neuman obtained ſix ounces, two drams of ſpirit, two ounces and two drams of ſalt, one ounce two drams of oil, and a reſiduum, from which, after calcination, twenty-ſix grains of ſaline matter were elixated.

(*y*) FENNEL. The leaves and ſeeds of common fennel contain an eſſential oil. The oil obtained from the leaves on the upper part of the plant is much finer, lighter, and more ſubtle than the oil obtained from the lower leaves. The former oil ſwims on water, and the latter oil ſinks. *Neuman.*

(*z*) FENUGREEK. The ſeeds of this plant contain an expreſſible oil blended with reſin and mucilage, but no eſſential oil. From ſixteen ounces, eleven drams were extracted by water; and from the ſame quantity, four drams and a half were extracted by ſpirit of wine. *Neuman.*

having undergone the ſpirituous fermentation, has proceeded to the acid fermentation, cannot be again made to undergo the ſpirituous, but paſſes neceſſarily to the putrid. Alſo thoſe ſubſtances which have undergone the acid fermentation directly, that is, without previouſly paſſing through the ſpirituous, are only then ſuſceptible of the putrid, and not of the ſpirituous fermentation; and the ſubſtances which paſs directly to the putrefactive fermentation cannot be made to undergo, at leaſt ſenſibly, the acid, and ſtill leſs the ſpirituous fermentation. Laſtly, any matter ſuſceptible of the ſpirituous fermentation cannot be made to putrify without previouſly paſſing through the ſpirituous and acid fermentations.

Theſe conſiderations have induced moſt chemiſts, and particularly the great Stahl, to conſider theſe fermentations leſs as three operations diſtinct and independant of each other, than as three principal and diſtinguiſhed degrees of one and the ſame fermentative motion, by which nature endeavors to reſolve, and to reduce into a ſimilar condition, all the moſt compounded bodies, into the combination of which enters the oily principle; that is, all animal and vegetable ſubſtances.

We may add, that while vegetable and animal ſubſtances ſuſceptible of fermentation make part of the living vegetable or animal, they undergo fermentation only in a ſlow and inſenſible manner; becauſe they are preſerved from it by the vital motion, and becauſe this ſlowneſs is neceſſary for the vegetable and animal economy: but when the life of organiſed bodies ceaſes, then, as nothing in their juices or proximate principles prevents their diſpoſition to change their nature and to be decompoſed, all theſe ſubſtances ſenſibly acquire the fermentative motion, and paſs with more or leſs rapidity and regularity through the periods of change which they have ſtill to undergo, according to the concurrence of circumſtances which generally favor fermentation.

According to this idea, fermentation, taking it altogether, would be nothing elſe than putrefaction; to which all animals and vegetables naturally and continually tend, during their life, ſlowly and inſenſibly; but after their death, quickly and ſenſibly.

At the beginning of this article we obſerved what the neceſſary conditions were for fermentation of any body, and hence the means by which it may be prevented or ſuſpended are eaſily deduced. Theſe means are, intenſe cold, want of air and of water, and, laſtly, a diſproportion of the principles of the bdoy expoſed to fermentation.

The moſt fermentable liquors, as the juices of grapes and other ripe fruits, do not ferment when expoſed to too great cold. The blood and fleſh of animals are preſerved from corruption by froſt. They may be alſo preſerved under the exhauſted receiver of an air-pump, or by drying perfectly. They may particularly be preſerved by this latter method any time, without ſuffering the leaſt alteration.

We are to remark upon this ſubject of preventing fermentations in fermentable ſubſtances, that when only the neceſſary degree of heat is employed to deprive them of their ſuperabundant moiſture, and their compoſition conſequently is not changed; we may, by mixing them again with the proper quantity of water, reſtore to them the ſame tendency to ferment which they had before they were dried. This obſervation is particularly applicable to matters ſuſceptible of the firſt and laſt degrees of fermentation, and we ought to conclude from thence, that although the products of the ſpirituous and alkaline fermentation are more volatile than water, yet the fermentable ſubſtances contain no principle which is not leſs volatile than water.

The laſt method of preventing or retarding fermentation in fermentable ſubſtances is, as we ſaid, to change the proportion of their proximate principles, which is conveniently done by mixing them with ſome ſubſtance which can unite itſelf to theſe principles, and which is not itſelf fermentable. Such are ſpirit of wine, acids, and even all ſaline ſubſtances. For this reaſon wine is preſerved in the ſame ſtate by penetrating it with ſulphureous acid; and alſo animal matters are preſerved from corruption by mixing them with ſpirit of wine, common ſalt, or any other ſalts.

Thoſe vegetable and animal ſubſtances only are properly fermentable which contain oil. The action of minerals, or of their principles on each other, nor even the action of decompounded vegetable and animal ſubſtances, can be conſidered as true fermentations, except we ſo far extend the meaning of the word fermentation as to include the ſpontaneous and inteſtine motion of decompounding pyrites, by which new ſalts are formed; the changes produced upon the imperfect metals by air and by water; the rancidity of oils; and other changes, which appear to differ eſſentially from the fermentation of animal and vegetable matters.

The efferveſcences which happen betwixt bodies not much compounded, when they mutually diſſolve each other, ſuch as the efferveſcences perceived when acids unite with earths, alkalis, or metals, are much more different from true fermentation, and have never been confounded together but by perſons entirely ignorant of chemiſtry.

We may judge from what we have ſaid concerning fermentation in general, how important this matter is for the attainment of a knowledge of animal and vegetable ſubſtances; but we cannot form an adequate notion of it, without conſidering attentively the particular phenomena which appear in the ſeveral kinds or degrees of fermentation. Wherefore, upon this the articles KINGDOM (VEGETABLE), KINGDOM (ANIMAL), WINE, SPIRIT of WINE, TARTAR, VINEGAR, *and* PUTREFACTION, may be conſulted.

CCXCV. FILTRATION and FILTERS. Filtration is an operation by which the heterogeneous parts mixed with a liquor are ſeparated, or by which certain matters are freed from an uſeleſs liquid. Filtration is generally performed by means of filters. A heap of ſmall parts of any ſubſtance, as ſand, may alſo be employed for filtration in ſome caſes.

The rules of filtration are very ſimple. The chief of theſe are, that the filter ſhall contain nothing which the liquor that paſſes through is capable of diſſolving; that it ſhall [illegible] be liable to be attacked or corroded by the liquor; and that its pores ſhall be ſmaller than the particles of the matter to be ſeparated from the liquor.

A liquor cannot be filtrated unleſs its fluidity and thinneſs be proportioned to the pores of the filter. Liquors which are viſcid and thick, as ſyrups and mucilages, and thoſe which are very thick, as very ſtrong ſolutions of ſome ſalts, do not paſs, or with great difficulty, through filters whoſe pores appear otherwiſe ſufficiently large in proportion to the fineneſs of their parts. This proceeds from the adheſion which theſe parts have to each other.

The filtration of theſe liquors is generally much forwarded by heat. Strong ſolutions, for inſtance, of ſalts, large proportions of which are ſoluble in water, as nitre, Glauber's ſalt, and others, require to be filtrated when boiling hot.

When the parts of a matter diffuſed in this liquor adhere to this liquor, they cannot be ſeparated by filtration. This adheſion muſt be previouſly deſtroyed. For inſtance, the expreſſed juices of plants are impregnated with a reſinous, earthy, fine matter, adhering to theſe juices, and deſtroying their tranſparency. The whey of milk alſo is turbid from the many fine caſeous parts adhering to it. Theſe liquors cannot be clarified by filtration without a previous preparation; for they cannot paſs through the pores of a filter cloſe enough to retain the heterogeneous particles which diſturb their tranſparency; and through a filter open enough to give them paſſage, they would paſs in their turbid ſtate.

Such liquors are rendered capable of filtration by coagulating and collecting [illegible] heterogeneous parts. This is effected by boiling, and ſtill better by whites of eggs mixed and boiled together with theſe turbid liquors. Whites of eggs, when they coagulate, collect and agglutinate the heterogeneous parts, which then appear in larger molecules, and float freely in the liquor without adhering to it. This liquor is then in a ſtate of filtration, it paſſes clear, and the matter which rendered it turbid remains upon the filter. The fine caſeous parts which diſturbed the tranſparency of whey are ſo well mixed in it, that, beſides whites of eggs, ſome cream of tartar muſt be added, to procure the required [illegible]ration.

[illegible] uſed as filters are woollen ſtuffs, linen cloths more or leſs [illegible] and [illegible] paper. The form of filters varies according to the quality and quantity of the [illegible]ers to be filtrated. Some of them are hollow inverted cones. [illegible] are uſed in pharmacy and cookery than in chemi[illegible] are filtered. The filter moſt frequently uſed [illegible] chemiſtry is paper, in the making of which no paſte or ſize has been [illegible]ployed.

[illegible] only of matter is to be filtrated, the paper muſt be [illegible]orm of a funnel, and to be placed in a glaſs funnel, [illegible] filter and the ſides of the funnel, to prevent [illegible]mediately and in all its extent to the funnel,

[illegible] a cloth is to be fixed to the four corners [illegible] be ſtretched tight: to the cloth is fitted paper, upon wh[illegible] poured.

The firſt port[illegible] li[illegible] filtration are almoſt always more or leſs t[illegible]ured again upon the filter, and even more [illegible]ctly clear. This happens becauſe the pores of the filter, [illegible] or [illegible] afterwards contracted by the ſwelling occaſioned by the liquor, [illegible] ſtopped up by the ſediment which is depoſited upon t[illegible]

CCXCVI. FIRE. Chemiſts conſider fire, as alſo the other elements, in two very different views; firſt, as it enters into the compoſition of many bodies, of which it is a principle or conſtituent part; and ſecondly, as being pure, free, not entering into any compound, but acting ſenſibly and ſtrongly upon all natural bodies, and producing effects as a powerful agent in all chemical operations. In this latter point of view we ſhall conſider fire in this article. It will be conſidered as a principle under the article Phlogiston.

Pure, free, uncombined fire ſeems to be a collection of particles, the matter of which is ſimple, homogeneous, and entirely unalterable. All the properties of this element ſhew that its particles are infinitely ſmall, have no ſenſible adheſion to each other, and that they have a very rapid, continual motion in all directions, which is eſſential to them.

From this definition, fire appears to be a body eſſentially fluid, and many facts concur to prove that it is the only body eſſentially fluid, conſequently the cauſe of the fluidity of other bodies; and that as it alone counterballances the general tendency of all the other parts of matter towards each other, they are prevented by it from uniting into one immenſe, homogeneous, and perfectly hard maſs.

Whence can ſo aſtoniſhing a difference proceed between the properties of the primitive integrant molecules of fire, and thoſe of the integrant parts of all other matter? Is fire then not material, or not compoſed of matter, as its properties have induced ſome philoſophers to think? Is it matter of a peculiar kind? Or does, as a great geometrician thinks, the attraction of the parts of matter become negative, and changed into repulſion, when theſe parts become infinitely ſmall, and can come infinitely near to each other; which ſeems very probably to be the caſe with the particles of fire?

We have not facts enough to decide concerning theſe different opinions. We ſhall, therefore, confine ourſelves to inveſtigate the eſſential properties of fire, chiefly thoſe which influence moſt in chemical operations and chemical phenomena.

Fire can with great facility penetrate, or ſeparate itſelf from, any body however denſe; that is, any body whatever may be heated by expoſure to fire; or cooled to its former temperature, by removing it from this expoſure.

From this effect we may infer the infinite ſmallneſs of the integrant parts of fire; and we may perceive the cauſe of its equal diſtribution through all bodies, when it is not determined by ſome particular cauſe to penetrate one body in greater quantity than another.

In fact, all ſubſtances whatever, which are placed in any given degree of heat, and obliged to remain there, acquire preciſely the ſame degree of heat. This fact has been aſcertained by inſtruments fit for meaſuring the degrees of heat.

The effects which the fire produces, or rather heated bodies, upon our ſenſes, are ſenſations of heat and light; but theſe ſenſations are not excited but when the fire is in a certain quantity; for every known body contains a certain portion of uncombined fire, and yet not any body which is not lighted or ſtrongly heated, excites in us any ſenſation of heat or light. Beſides, in certain circumſtances, a body may appear luminous, although it has no more ſenſible heat than the ſurrounding bodies. This is proved by the effects of ſeveral phoſphoric bodies, ſuch as the ſcales of fiſh, rotten wood, glow-worms; all which ſhine in the dark, although no more heated than the ſurrounding bodies. Alſo certain ſubſtances may be ſo penetrated with free and active fire, as to excite ſenſations of heat, and even to burn, although they do not appear luminous even in the dark. Amongſt theſe ſubſtances are ſtones, metals, and even water, all which may be ſo heated as to excite pain to perſons touching them, although they are not luminous.

Hence we ought to conclude, that the ſenſations of heat and light are in many caſes inſufficient to prove the preſence of any given quantity of fire in bodies.

We ought alſo to remark, that although all bodies penetrated with much fire are neceſſarily hot and luminous; heat, and not light, is the only certain ſign of the preſence of fire. The reaſon of this is, that bodies may be very luminous, without any change being induced into any of their eſſential qualities in theſe two contrary ſtates; whereas the difference of more or leſs heat produces in all bodies alterations of their properties very ſenſible and proportionable to the difference of heat.

Theſe conſiderations ſeem to have induced ſome philoſophers to imagine, that light is a being which is indeed rendered ſenſible by fire, but diſtinct and different from it. According to this opinion, heat is only a property of fire; whereas light is a diſtinct and independant ſubſtance. This opinion appears to be even demonſtrated, when we conſider that light may be decompoſed by refraction, as Newton's experiments ſhew; and that it is not, as pure fire is, capable of pervading all bodies, is proved by the opacity of many bodies, and by the reflexion of light.

However that may be, as heat occaſions more or leſs ſenſible changes in the qualities of all bodies; and that its whole action by which it influences any body conſiſts in the ſimple quality, or, to ſpeak more accurately, the eſſential fluidity of fire, of which heat is only an effect; we ought here only to conſider the general effects produced by fire upon all bodies by heating them more or leſs.

Theſe effects, although diverſified, depend nevertheleſs on one principle and primary change produced upon all bodies, by which they are rarefied or made to occupy a larger ſpace. In fact, every ſolid and fluid body, when penetrated by a greater or leſs quantity of diſengaged fire, is more or leſs encreaſed or diminiſhed in ſize than it was before.

This principle has ſuggeſted to philoſophers ſeveral different inſtruments by which this dilatation of heated bodies, or rather the heat which is the cauſe of it, may be meaſured; and quantities of fire, too ſmall to be eſtimated by our ſenſes, may be appreciated. The chief of theſe inſtruments is the THERMOMETER; *which ſee.*

As bodies are dilated by fire, their ſpecific gravity muſt conſequently be diminiſhed, and the adheſion of their integrant parts muſt alſo be diminiſhed. *See* AGGREGATION, INTEGRANT PARTS, *and* GRAVITY.

Theſe two great effects, produced by fire upon all bodies, are the moſt important and moſt neceſſary to be conſidered, relatively to chemiſtry. We may indeed ſay, that they are the only effects; for excepting combuſtion, which is a peculiar property of inflammable bodies, every chemical operation is performed either by a diminution of ſpecific gravity, or by a greater or leſs disjunction of the integrant parts of bodies, as we ſhall ſee.

Some ſubſtances are capable of a greater dilatation or diminution of their ſpecific gravity, than others, by fire. Thus certain matters are ſo much rarefied by even a moderate heat, that they ſeem to loſe all their ſpecific gravity, or become at leaſt ſpecifically lighter than all the ſurrounding bodies: hence theſe ſubſtances, when heated to a certain degree, are raiſed as bodies would be without gravity. All ſubſtances which have this property are called in general *volatile ſubſtances.* *See* VOLATILITY. Other bodies are ſo little dilatable by fire, relatively to their denſity, that the greateſt heat that can be given to them produces an almoſt inſenſible diminution of ſpecific gravity. Theſe are called, from their being almoſt unalterable in this reſpect by fire, *fixed bodies.* *See* FIXITY.

Hence, if we expoſe to fire a compound body containing ſome fixed and ſome volatile principles, the former becoming ſpecifically lighter ought to riſe in vapors, and to ſeparate themſelves from the latter, which are unalterable in this reſpect. But as almoſt all compounds contain principles differing ſo much in volatility and fixity, that ſome of them may be raiſed and ſublimed, while others ſhall remain fixed with ſome given degree of heat; we may therefore, by heat alone, make many analyſes and decompoſitions. If, for example, we expoſe a compound of regulus of antimony, which is a volatile ſemi-metal, and of gold, which is a fixed metal, to a heat ſo ſtrong that the volatility of the regulus of antimony ſhall take place; then this ſemi-metal, being raiſed by its acquired levity, will be ſublimed in vapors, and will be ſeparated from the gold, which will remain fixed and pure. *See* DISTILLATION, SUBLIMATION, EVAPORATION.

The obſervation we have juſt made concerning the changes in the ſpecific gravity of bodies, which the dilatation occaſioned by heat produces, ought alſo to be applied to the diminution of the adheſion of their integrant parts, which is an effect of the ſame cauſe; for if a body be dilated by heat, the contiguity, and conſequently the adheſion, of its integrant parts muſt be diminiſhed: but in this reſpect the ſeveral natural ſubſtances differ very much; for the integrant parts of ſome bodies, when dilated by heat, are ſo ſeparated and disjoined, that they ſeem no longer to cohere. If theſe bodies be naturally ſolid, they become fluid when they are penetrated with a ſufficient quantity of diſengaged fire, and are called *fuſible bodies.* Thoſe bodies, the integrant parts of which cannot be entirely disjoined by fire, are called infuſible or refractory: but as the aggregation of a body is broken when it is fuſed, and as this deſtruction of aggregation is a neceſſary condition for the combination of bodies with each other; fire therefore, by rendering ſolid bodies liquid, has influence as a principal agent in all combinations. *See* COMBINATIONS, SOLUTIONS, FUSIBILITY, and REFRACTORY.

As all chemical operations may be reduced to decompoſitions and combinations, fire is therefore in chemiſtry, as in nature, an univerſal agent. Thus we know that, although decompoſitions and analyſes may be made by menſtruums without any more than the natural heat, yet as thoſe menſtruums can only act when rendered ſufficiently fluid by heat, fire therefore acts in theſe analyſes as neceſſarily as in thoſe which are occaſioned by the immediate application of heat.

We ought to obſerve concerning this ſubject of the volatility, fixity, fuſibility and infuſibility of bodies, firſt, that all theſe qualities are properly only relative. Not any body is entirely fixed and unfuſible, and thoſe which we conſider as ſuch would be reduced into vapors, as volatile bodies are, if they were expoſed to a heat infinitely ſtronger than any we can excite. Thus a body will appear fixed, or infuſible, when compared with other very volatile and very fuſible ſubſtances; while it ſhall be conſidered as volatile or fuſible, when compared with others more fixed and leſs fuſible.

In the ſecond place, as volatility and fuſibility are effects of one and the ſame cauſe, namely, of the dilatation occaſioned by the preſence of a certain quantity of uncombined fire in bodies, theſe two qualities are properly the ſame, in more or leſs eminent degrees; and in this ſenſe, volatility ought only to be conſidered as the higheſt degree of fuſibility. Accordingly, ſubſtances which are habitually liquid, and which ought therefore to be conſidered as the moſt fuſible, are all very volatile, and may be raiſed into vapors with very little heat; while, on the contrary, matters that are hard, and not very dilatable; thoſe, in ſhort, the aggregation of whoſe parts is the firmeſt and moſt difficultly to be broken, and which are therefore the leaſt fuſible, are alſo the moſt fixed.

The aggregation of all bodies, when reduced into vapors or fuſed, is broken, but more ſo when reduced into vapors, than when merely fuſed. Accordingly, the moſt effectual of all methods for combining ſubſtances which cannot be eaſily united, or which cannot be joined while the aggregation of one of them is ſenſibly preſerved, is, if poſſible, to reduce them into vapors, and to make their vapors meet.

All the effects which fire produces, as an agent in chemical operations, are reducible, as we ſee, to thoſe we have mentioned. The quantity of uncombined fire which flows perpetually from the ſun, and diffuſes itſelf through all its ſphere, is ſufficient to produce all the ſeparations and combinations which we daily ſee effected by nature: but as the heat cauſed by the ſun is very limited, chemiſtry would be confined almoſt to the contemplation of natural operations, if we had not methods by which pure and uncombined fire may be made to enter bodies, or to quit them in greater or leſs quantities.

The methods of encreaſing the quantity or the activity of uncombined fire in bodies may be comprehended in the following three:

Firſt, by concave mirrors and by convex glaſſes, a number of the rays of the ſun, proportionate to the ſize and good quality of the inſtruments, may be collected into one point, called the *focus*. Bodies expoſed to ſuch a focus are penetrated with an infinitely greater quantity of uncombined and active fire than they have naturally. They are then ignited, inflamed, dilated, fuſed, or volatiliſed, according to their particular natures. The heat of ſuch a focus is the greateſt that art has produced. It is even exceedingly too ſtrong for moſt chemical operations, and ought to be applied to the moſt fixed and refractory bodies only. As ſuch a focus is alſo very ſmall and inconvenient for the performance of any operation, and as large mirrors and lenſes are very rare and dear, this fire is not much uſed for chemical operations. Nevertheleſs, ſeveral very important chemical experiments were performed by collected ſolar heat; as the decompoſition of gold, publiſhed by Homberg, if it be true; the fuſion of platina, by Meſſrs. Macquer and Beaumé; and of ſeveral other bodies which could not be fuſed by other fires, without addition of other ſubſtances, by other chemiſts, at different times.

Secondly, experience has long ago taught us, and even the moſt ignorant nations know, that heat and all the effects of fire may be occaſioned by friction and percuſſion of hard bodies. The heat excited by this method may be very conſiderable, and even comparable to that of collected ſolar fire. It is in general proportionable to the force, rapidity, intenſity of friction and of percuſſion, and to the hardneſs of the bodies rubbed or ſtruck. This heat is alſo not much uſed in chemical operations: it, however, frequently occurs in many chemical experiments, as in fermentations, efferveſcencies, and ſolutions. It occurs whenever bodies unite together; and is proportionable to the rapidity and force with which they act upon each other. It is produced by the friction and colliſion of their integrant parts; which ſhows, that the primary integrant parts are exceedingly hard, even in bodies generally ſoft or fluid; for theſe ſubſtances, when diſſolving, produce as much heat as thoſe which are moſt hard, and whoſe aggregation is moſt firm.

The third cauſe which produces or excites heat is the combuſtion of compound bodies, in the combination of which fire enters as an element or principle, and which are therefore called inflammable or combuſtible bodies.

The principal phenomenon preſented by theſe bodies is, that by mere contact with any other body, inflammable or not, but which is ignited, they are kindled, inflamed, give much heat and light; in a word, produce all the ſame effects as the collected ſolar heat, or the alliſions of hard bodies. This continues till the whole ſubſtance of fire, which entered into their compoſition, and which was inactive, has reſumed all the activity of pure and uncombined fire, and is entirely diſſipated.

This inflammation of combuſtible bodies is undoubtedly one of the greateſt and moſt aſtoniſhing phenomena of nature: but it is alſo one of the moſt difficult to be conceived. We cannot expect to underſtand it well, till we know better than we do at preſent the eſſence and true ſtate of fire when combined, and conſtituting a principle of the bodies containing it, called *phlogiſton*. *See* Phlogiston.

We muſt obſerve at preſent, that as the combuſtion of inflammable bodies produces all the effects of fire, pure, uncombined, and active; it is alſo the moſt convenient method, by which fire can be applied by chemiſts to ſeveral bodies.

The moſt common inflammable ſubſtances, ſuch as wood, foſſil coal, charcoal, are moſt generally employed in chemiſtry, in the arts, and in the ordinary purpoſes of life, in all operations where fire is requiſite.

As chemiſts have occaſion to employ all the ſeveral degrees of heat, from the weakeſt to the ſtrongeſt, they have diſcovered methods of applying any required degree through intermediate ſubſtances, and ſtill better by the diſpoſition and conſtruction of furnaces, in which the combuſtible matters, and thoſe to which the fire is intended to be applied, are contained. *See upon this Subject* Baths, Combustion, Furnaces. (a)

CCXCVII. FISH. (b)

(a) *See the Supplement* I. *article* Fire.

(b) Fish. Neuman obtained from ſixteen ounces of fiſh analyſed by diſtillation, thirteen ounces two drams and a half of volatile alkaline ſpirit, five drams of concrete ſalt, three drams of oil, and an ounce four drams and a half of reſiduum, from which, by calcination and elixation, twenty-five grains of ſaline matter were extracted. The proportion of volatile ſalt thus obtained from fiſh is conſiderably greater than that from fleſh.

CCXCVIII. FIXITY. Fixity is a property, by which a body reſiſts the action of fire, without being raiſed and diſſipated in vapors. It is the oppoſite quality to volatility.

The degree of reſiſtance which a body ought to give to fire, to entitle it to the character of being fixed, is not determined. Thus ſubſtances are conſidered to be fixed almoſt always relatively to others which are leſs fixed.

As we do not know the ultimate degrees of the activity of fire, we cannot ſay whether any bodies in nature be capable of reſiſting this extreme degree of fire without ſublimation, or be abſolutely fixed.

Thoſe ſubſtances, however, are generally conſidered by chemiſts as abſolutely fixed, which loſe nothing of their quantity by expoſure to the moſt intenſe heat which they can produce. The pureſt and ſimpleſt earthy principle is a ſubſtance of this kind, and is perhaps the only one which can be conſidered as naturally fixed, and is the principle of fixity of all the reſt.

Chemiſts commonly call many ſubſtances fixed, which do not deſerve that name, but comparatively with others, as we have already mentioned. In this ſenſe, for inſtance, vitriolic acid is ſometimes called a fixed acid, by which is only meant that it is leſs volatile than others. For the ſame reaſon, regulus of antimony, and other ſemi-metals, may be conſidered as fixed ſubſtances when compared with eſſential oils and ether, particularly in operations where they remain fixed, when expoſed to a heat ſufficient to evaporate eſſential oils or ether; whereas theſe ſemi-metals may be conſidered as volatile, when compared with metals properly ſo called.

The fixity of bodies ſeems certainly to proceed from their little dilatability by fire, and this defect of dilatability is occaſioned by the attraction or adheſion of the integrant parts of theſe bodies. *See* FIRE *and* VOLATILITY.

CCXCIX. FLAME. Flame is a collection of vapors of combuſtible bodies actually burning, and which are themſelves in the motion of combuſtion. (c)

(c) FLAME is generally ſaid to be an ignited vapor, or red-hot ſmoke. Nevertheleſs, *Flame*, *Vapor*, and *Smoke*, are things diſtinct from each other, and ought not to be confounded together. We ſhall endeavor to deſcribe and diſtinguiſh theſe; and firſt, of *Vapor*.

By the action of certain determinate degrees of heat, with or without acceſs of air, all liquid and ſome concrete bodies are ſo dilated, as to occupy a much larger ſpace than before this expoſure to theſe determinate degrees of heat; acquire a conſiderable expanſive power, or elaſticity; and become tranſparent and inviſible. They are then properly vapors. This ſtate they retain while expoſed to the ſame heat by which it was produced; but by application of cold, they are condenſible into palpable ſubſtances, ſimilar to thoſe from which they were formed, if they happened to conſiſt of homogeneal parts, as water and mercury do; or they are condenſible into palpable ſubſtances which are the conſtituent parts of the bodies ſubjected to heat, if theſe bodies happened to conſiſt of parts not homogeneal, as plants do of water and eſſential oil. If the vapor conſiſts of inflammable parts, it may be kindled by contact with any ignited body; by which means, together with acceſs of air or nitrous acid, it may be made to undergo thoſe effects which are produced upon all bodies during their combuſtion, namely, the decompoſition of its parts, the diſſipation of its phlogiſton, and emiſſion of heat and light: but vapor thus ignited, rendered viſible, and in the act of combuſtion, by acceſs of air, or nitrous acid, is *flame*. This flame, or vapor decompoſed by combuſtion, is not condenſible, as we may eaſily conceive, into ſuch palpable

As bodies cannot burn but by touching immediately the air, and as for this reaſon they only burn at their ſurface, flame, which is the only truly burning part of bodies which appear in actual combuſtion, is always at their ſurface. It is luminous and ardent throughout its whole thickneſs, becauſe it is only a maſs of adjacent, but diſunited inflammable parts, which touching the air on every ſide, burn altogether and throughout their whole ſubſtance.

ſubſtances as the undecompoſed vapor is; but into ſome only of the conſtituent parts of theſe ſubſtances, the reſt being deſtroyed by the combuſtion. Thus the vapor of ſpirit of wine is again condenſible into ſpirit of wine; but from the flame of ſpirit of wine little can be obtained by condenſation but the water, which was one of the conſtituent parts of that ſpirit; the other parts, eſpecially the phlogiſton, being deſtroyed by the combuſtion.

Not only the vapor of an inflammable body, but alſo the inflammable body itſelf, without being previouſly changed into vapor, may, by contact with an ignited body, or any other mode of application of heat, as friction, percuſſion, &c. together with acceſs of air or nitrous acid, emit a flame, which conſiſts, as in the former caſe, of particles of that body in the act of combuſtion. Thus by applying a hot iron to ſulphur, we may ſee a flame immediately produced upon the ſurface of the ſulphur. We may eaſily conceive that bodies thus kindled can only flame at their ſurfaces, becauſe there only they are contiguous to air: but when nitre is intimately mixed with the inflammable ſubſtance, as in gun-powder, the whole ſubſtance, its interior as well as its exterior parts, are inſtantly inflamed; becauſe the nitrous acid has, like air, the property of maintaining combuſtion. Hence alſo we may eaſily conceive why the external ſurface of a flame, by being contiguous with air, is much hotter than its internal parts, as may eaſily be ſhewn by applying any ſubſtance, alterable by heat, alternately to the exterior and interior parts of the flame of a candle; and when the flame has a conſiderable diameter, as of a foot or eighteen inches, and is maintained only by the air contiguous to it, as when the vapor iſſuing at the upper mouth of a furnace for ſmelting iron ore is kindled by contact of any ignited body, the flame will then be found to have a thickneſs only of an inch or two, while the vapor near the center ſurrounded by this flame, is not inflamed, as appears from paper or other eaſily combuſtible matter being held in it without being kindled.

Smoke conſiſts of palpable particles elevated by means of the rarefying heat, or by the force of the aſcending current of air, from bodies expoſed to heat. Theſe particles vary much in their properties according to the ſubſtances from which they were produced. Vapors alſo riſing from heated bodies, when condenſed by the coldneſs of air or other contiguous bodies, become palpable, and therefore have the appearance, and may be conſidered as ſmoke. The ſmoke ariſing from combuſtible bodies conſiſts of parts, ſome of which are generally combuſtible, but ſo difficultly combuſtible, that a greater heat is required than they poſſeſs while they are ſmoke, to effect their combuſtion. The flame alſo of combuſtible bodies may be ſo cooled by the application of cold air, or other cold ſubſtances, as that the combuſtion of the particles compoſing it ſhall be checked, and theſe particles ſhall become ſmoke. Thus the flame of a candle is, by the coldneſs of the air, diminiſhed more and more as it riſes higher, till at laſt it is extinguiſhed, before all its inflammable parts are conſumed, and its point terminates in ſmoke.

The ſmoke of burning inflammable ſubſtances, when collected, is called *ſoot*. The ſmoke of uninflammable ſubſtances, or of inflammable ſubſtances not expoſed to air, and conſequently not burning, conſiſts of the ſubſtances not altered or decompoſed, but only divided, as the flowers of ſulphur raiſed by heat in cloſe veſſels, and the flowers of ſal ammoniac; or it conſiſts of parts of theſe ſubſtances decompoſed merely by heat, and not by combuſtion; as the flowers of ſulphur and of arſenic, from the mineral containing theſe called pyrites, expoſed to heat in cloſe veſſels; and the flowers of benzoin, ſublimed by heat from the reſin of that name.

No combuſtible body really burns without flame. Thoſe, indeed, whoſe inflammable principle is firmly united with a great quantity of incombuſtible matter, ſuch as charcoal or aſhes almoſt entirely burnt, and moſt metals, ſeem to be conſumed without ſenſible flame; but this appearance does not impoſe upon an accurate obſerver. The appearance of a body which really burns is very different from that of a body which is only made red-hot by being penetrated with a fire proceeding from ſome other ſubſtance, which does not itſelf burn. Let a bar of iron be compared with a flint, when both are taken out of a fire ſo intenſe as to give to each of them a white heat, and the ſurface of the metal will ſeem covered over with a ſmall flame, which is indeed very low, but bright and ſparkling; while nothing ſimilar will appear on the ſurface of the flint. Beſides, the flint will loſe its vivid color much ſooner than the iron. If we obſerve lead while it is ſcorified in a cupel under a muffle, we ſhall ſee in a ſtriking manner that the metal ſhall be much more ardent and luminous than the cupel; although theſe two bodies are expoſed preciſely to the ſame degree of heat; but this difference can certainly proceed only from the ſmall flame which neceſſarily accompanies the combuſtion of the metal; while the cupel which contains no combuſtible principle, and which conſequently cannot burn, does not exhibit any ſuch appearance.

All bodies, therefore, which do really burn, ſeem to burn with flame; but the flames proceeding from the different combuſtible bodies differ very much from each other, according to the nature of theſe bodies, and to the particular ſtate of their phlogiſton. I do not know whether the flame of any combuſtible body be entirely pure. Such a flame would be nothing elſe than phlogiſton ſeparated from all other ſubſtances, reduced into vapor, and actually ignited. The flames of rectified ſpirit of wine and of perfect coal ſeem to be the pureſt of all, becauſe they are accompanied with no ſmoke nor fuliginous matter. Nevertheleſs, the flame of ſpirit of wine is accompanied with much water. *See* SPIRIT *of* WINE. All other flames are evidently mixed with heterogeneous ſubſtances, which diſcover themſelves by different qualities.

The leaſt pure of all flames is that of oils and of all oily matters, becauſe it proceeds from very compound bodies. This flame is always mixed not only with all the volatile principles of the oil, or oily body, but alſo with a conſiderable quantity of the fixed principles which are raiſed by the deflagration. Beſides, although it is conſiderably luminous, all the phlogiſton which it contains is not burnt: a portion of it remains combined in the ſtate of coal with earth. Hence the flame of all oils is accompanied with a fuliginous ſmoke, which blackens bodies that it touches. As this property belongs to the flames of all oils and oily matters, and to none elſe, it is a mark by which we may diſcover whether the phlogiſton of any body be in an oily ſtate. *See* OIL, FULIGINOSITY, SMOKE, *and* SOOT.

The flame of metals is alſo accompanied with a ſenſible ſmoke, which is even very conſiderable and thick in certain metals. But this flame does not, like that of oils, blacken ſubſtances which it touches; becauſe metals are not in an oily ſtate. *See* METALS.

Laſtly, the flame of ſulphur would be very pure, if it was not for the vitriolic acid, a large quantity of which is mixed with it. Perhaps the flame of this compound would be very pure, if the ſulphur was previouſly mixt with fixed alkali to abſorb the acid, in Stahl's manner, and if it was made to burn ſo weakly as not to be capable of kindling combuſtible bodies. *See* Sulphur.

CCC. **FLINTS.** *See* Earhts (Vitrifiable). (*d*)

CCCI. **FLOWERS.** By this name is generally underſtood bodies reduced into very fine parts, either ſpontaneouſly, or by ſome operation of art; but it is applied chiefly to volatile ſolid ſubſtances, reduced into very fine parts, or into a kind of meal by ſublimation.

Some flowers are nothing elſe than the bodies themſelves, which are ſublimed entire, without ſuffering any alteration or decompoſition: and other flowers are ſome of the conſtituent parts of the body ſubjected to ſublimation, as we ſhall ſee in the following articles, when we define the principal matters diſtinguiſhed by the name of flowers.

CCCII. **FLOWERS *of* ANTIMONY.** Antimony, which is a mineral compoſed of the ſemi-metal called regulus of antimony and ſulphur, is entirely volatile, and capable of being ſublimed into flowers.

To make flowers of antimony, an earthen pot or large crucible, in the upper and lateral part of which is an opening, is placed in a furnace, and three or four aludels are fitted to it. The pot is to be made red-hot, and powdered antimony is to be thrown into it through the lateral opening, and the ſublimation is then to be made. Theſe projections of antimony are to be repeated till the operator judges that the inner ſurface of the aludels is ſufficiently covered with flowers, which are to be detached from thence with a feather.

The veſſels employed for this ſublimation muſt not be exactly cloſed, for two reaſons; firſt, that acceſs of air favors and accelerates all ſublimations, and particularly this. Lemery obſerves juſtly, that the operation is accelerated greatly by directing a blaſt of wind upon the ſurface of the antimony. In the ſecond place, if the veſſels were perfectly cloſed, they would be burſt by the expanſion of the vapors, or of the contained air.

Although flowers of antimony be compoſed of regulus of antimony and of ſulphur, as the antimony itſelf is, they nevertheleſs differ from it eſſentially in many reſpects. They have not the ſame metallic brilliancy. Their color is different ſhades of white, grey, and yellow. They are powerfully emetic. Theſe

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(*d*) Flints are ſemi-tranſparent or opake ſtones, generally of a roundiſh form, and covered with a white cruſt, of a ſmooth, uniform, ſhining texture, ſo hard as to ſtrike fire with ſteel; calcinable by fire, ſo as to become white, brittle, and, according to Henckel, heavier than before calcination; not ſoluble by acids; and vitrifiable only by the very violent heat of the largeſt ſpeculums, ſuch as that of Vilette, and not even by the focus of a lens of Tſchirnhaus, according to an experiment of Neuman. They are found generally in beds of chalk and of ſand, but never forming entire ſtrata of rock, as jaſper does. By long expoſure to air and to the ſun, they ſeem to decay, to loſe their luſtre, their firmneſs of texture, and to be changed to a white calcareous earth or chalk. Hence they are almoſt always found covered with a white chalky cruſt. They are alſo convertible into calcareous earth by fuſion, or vitrification with ſo much fixed alkali, that they ſhall reſolve into a liquid maſs called the liquamen of flints, and by precipitation from the fixed alkali by means of acids. *See* Liquor *of* Flints.

Flints are of the claſs of earths called *vitrifiable*, becauſe theſe earths are generally employed, together with fixed alkali, as materials in the making of glaſs. *See* Glass, *and* Earths (Vitrifiable).

difference

differences prove that antimony ſuſtains a conſiderable alteration by this ſublimation. This alteration conſiſts in the diminiſhing the connexion betwixt the ſulphur and the regulus of antimony.

The difference of colors in flowers of antimony proceeds from the variable action of the fire and of the air upon this mineral during the operation. Probably the emetic quality of flowers of different colors alſo differs. But this difference has not been obſerved, as the flowers of antimony have not been much employed, becauſe of their uncertainty.

CCCIII. RED FLOWERS *of* ANTIMONY. Lemery gives a proceſs for making the red flowers of antimony. It conſiſts in diſtilling eight ounces of antimony, mixed with fourteen ounces of ſal-ammoniac, or of flowers of ſal-ammoniac. Some volatile alkali is raiſed from the ſal-ammoniac, and red flowers are ſublimed.

The portion of volatile alkali which riſes in this operation is diſengaged by the reguline part of antimony; and as one part of this volatile alkali acts at once upon the ſulphur and upon the regulus of antimony, an antimoniated volatile liver of ſulphur is formed. Theſe red flowers are a kind of kermes, and differ from the ordinary kermes in having a volatile inſtead of a fixed alkali. They are emetic, purgative, diaphoretic, inciſive, &c. as kermes is, and may be given in the ſame doſe as kermes is; but are ſeldom uſed. However, a kermes made with volatile alkali may have peculiar virtues, and deſerves the attention of phyſicians; but in this caſe it ought to be prepared in a more certain manner by employing uncombined volatile alkali.

CCCIV. FLOWERS (ARGENTINE) *of* REGULUS *of* ANTIMONY. To make theſe flowers, regulus of antimony is put into an unvarniſhed earthen pot, which is to be placed in a furnace ſo that its bottom may be red-hot, while its upper part ſhall be much colder. The pot is to be covered with a lid, without luting it, and heat is to be applied during an hour or more. When the pot is cold, its internal ſurface, and alſo the remaining part of the regulus, is found covered with white flowers, in form of beautiful, tranſparent, and ſhining needles. Theſe flowers are to be gathered with a feather. After this, a ſecond ſublimation may be commenced, and managed as the former was; and thus the whole regulus may be changed into flowers, which requires much time.

Lemery directs that a ſmall lid or diaphragm ſhall be placed within the pot, at the height of three or four fingers thickneſs above the regulus. But this appears to be unneceſſary. Mr. Beaumé does not uſe this ſecond lid. He only inclines the pot ſo, that all the upper part of it ſhall be out of the furnace. He makes the bottom of it very hot; and thus obtains a large quantity of flowers.

Theſe flowers appear to be nothing elſe than the earth of regulus of antimony deprived of almoſt all its phlogiſton. They are not emetic nor purgative. They are not very volatile, and cannot eaſily be reduced into regulus. They are ſoluble in aqua regia. All theſe properties, together with their remaining degree of volatility, ſhew that they contain ſome inflammable principle. They have alſo conſiderable marks of a ſaline ſubſtance. They have not only the appearance of a cryſtallized ſalt, but are alſo entirely ſoluble in water, as Mr. Beaumé obſerves; although a large quantity of water, which muſt alſo be boiling, is required for that purpoſe. Eight ounces of boiling water are capable of diſſolving half a grain of theſe flowers. From this property we may ſuſpect that regulus of antimony contains a ſaline matter as one of its conſtituent parts, which is conformable to the opinion of ſome chemiſts concerning ſalts and metals.

Nevertheleſs, if we conſider that regulus of antimony cannot be deprived of all the ſulphur with which it is united in its mineral ſtate, we may ſuppoſe that part of the acid of ſulphur may, by uniting with the earth of the regulus of antimony, give the ſaline qualities to the flowers of this metallic ſubſtance.

CCCV. FLOWERS *of* ARSENIC. The white flowers of arſenic are nothing but white arſenic itſelf; which being a volatile ſubſtance, unalterable by ſublimation, may be raiſed altogether, without any change.

Flowers of arſenic are made, as all other flowers are, by ſubliming arſenic. *See* SUBLIMATION.

We ought to obſerve that they are not perfectly white, unleſs the arſenic from which they have been ſublimed has been perfectly dephlogiſticated and white. If the arſenic which is ſublimed be mixed with a little ſulphur, the flowers will be more or leſs yellow, or red, according to the quantity of ſulphur which is ſublimed along with them. If the arſenic be in a reguline ſtate, or conſiderably phlogiſticated, its flowers will be more or leſs greyiſh or brown. Hence we ſee veins of theſe different colors among the arſenic which is found in commerce, and which is obtained by ſublimation in great works from arſenical minerals.

As arſenic is very fuſible, when theſe flowers fix themſelves to any ſubſtance conſiderably heated, they ſuffer a kind of fuſion, are agglutinated together, and form the denſe, compact, heavy, ſhining maſſes which are in the ſhops of druggiſts. The nature and properties of flowers of arſenic do not differ from thoſe of arſenic. *See* ARSENIC.

CCCVI. FLOWERS *of* BENJAMIN, *or* BENZOIN. To make flowers of benjamin, let a quantity of benjamin be put into a varniſhed earthen pan, which is to be covered with another inverted pan of ſtone ware. The edges of theſe two pans ought to have been ground upon a ſtone, ſo that they fit well to each other. They are to be luted together with paper dipped in paſte. The earthen pan containing the benjamin is to be put upon a gentle fire, and which is not capable of raiſing the oil of the benjamin. With that heat the ſublimation is to be performed: when the veſſels are cooled, they are to be unluted, and great care is to be taken that they be not ſhook. If the ſublimation has been performed, the inner ſurface of the upper earthen pan will be found covered with fine ſparkling flowers like a very pure ſalt, forming cryſtals like flattened needles. A conſiderable quantity alſo of theſe flowers is generally found, which are not raiſed, and which cover the ſurface of the remaining benjamin. The flowers are to be ſwept off with a feather.

The ſucceſs of this operation depends on the degree of heat given, and the time employed. If the heat be too great, a part of the oil of benjamin will riſe together with the flowers, which will thence receive a dirty yellow tinge. In this caſe they muſt be again ſublimed, and with a leſs heat. If, on the contrary,

trary, a ſufficient degree of heat is not given, or the operation has not been long enough continued, all the flowers which the benjamin is capable of furniſhing will not be procured. The ſame benjamin will, by repeating the operation, furniſh more flowers.

The proceſs formerly uſed to make theſe flowers conſiſts in putting the benjamin in an earthen pot, to the mouth of which is fitted a paper, or paſteboard conical head. But the method deſcribed above, which is propoſed by Mr. Beaumé, ſeems to be preferable; becauſe the paper or paſteboard heads abſorb many flowers, which are conſequently loſt; and alſo becauſe the earthen veſſel employed by Mr. Beaumé has a greater ſurface than the pot uſed in the ancient method; and quantity of ſurface is always favorable to ſublimation.

The flowers of benjamin are a true concrete, volatile, and oily eſſential ſalt of benjamin. They have the ſmell of benjamin, and are inflammable, from the eſſential oil which enters their compoſition. They are ſoluble in water and in ſpirit of wine, which ſufficiently proves their ſaline nature. Accordingly, Mr. Geoffroy obſerves, that this ſalt may be obtained by treating benjamin with water, and by cryſtalliſation.

Benjamin is probably not the only reſin from which an eſſential ſalt of this kind may be obtained; perhaps, even all reſins contain ſuch eſſential ſalt, in greater or leſs quantity; and this is certainly one of thoſe which contain a great quantity of it.

Flowers of benjamin are conſidered in medicine as inciſive, dividing, and favoring expectoration; and are therefore given in the viſcous aſthma. They may be given from ſix grains to twelve. *See* Resins, *and* Sublimation.

CCCVII. FLOWERS *of* SAL AMMONIAC. The flowers of ſal ammoniac are nothing elſe than ſal ammoniac ſublimed; for this ſemi-volatile ſalt ſuffers no decompoſition by ſublimation. The proceſs for making theſe flowers contains nothing ſingular, excepting that an equal part of decrepitated common ſalt is generally mixed with the ſal ammoniac, in order to divide this latter ſalt, and to facilitate its ſublimation. By this ſublimation, ſal ammoniac may be purified from fuliginous and other matters, with which it is generally mixed. But it may be better and more conveniently purified by ſolution in water, by filtration, and by cryſtalliſation. For this ſalt has the property of raiſing along with it in ſublimation very fixed matters, as we ſee from the example of the flowers of ſal ammoniac tinged with copper and with iron, called *ens veneris* and *ens martis*, which are nothing elſe than ſal ammoniac ſublimed with theſe metals. *See* Ammoniac (Sal).

CCCVIII. FLOWERS *of* SULPHUR. Flowers of ſulphur are [illegible] ſublimed in [illegible] of ſhades. Sulphur cannot be decompoſed [illegible] ſubſtance, in cloſe veſſels. Therefore flowers of ſulphur [illegible] from thoſe of pure ſulphur in maſſes. [illegible]

CCCIX. FLOWERS *of* ZINC. Flowers of zinc are the metallic [illegible] its phlogiſton, and raiſed in light flocks from [illegible]

To make theſe flowers, zinc is to be put into a large open crucible, ſet in a furnace which draws well. When a white heat is raiſed, the zinc kindles and burns with a white, vivid, dazzling flame, accompanied with a conſiderable quantity of white ſmoke. This ſmoke is condenſed in white light flocks, which float all round the laboratory. The greateſt part of theſe flocks, however, fix themſelves to the ſides of the crucible and to the zinc. They are called *flowers of zinc, nihil album*, or *pompholix.*

Although theſe flowers are raiſed into ſmoke in this operation, like a very volatile ſubſtance, they are really very fixed, as metallic earths are, when well dephlogiſticated; and are ſo incapable of being again ſublimed, that they reſiſt the moſt violent fire, and are ſooner melted than ſublimed. If they are then raiſed in ſmoke during deflagration, this effect is produced by the activity with which the zinc burns; and for the ſame reaſon, earths and coals extremely fixed are found in ſoot of wood and of moſt other combuſtible matters.

The flowers of zinc are ſoluble in acids, nearly as zinc is. *See* ZINC. The cauſe of this may be, that they retain ſome phlogiſton. But they are difficultly reducible into zinc, and were even believed to be incapable of reduction, till Mr. Margraaf publiſhed a method of reviving them, by expoſing them to a ſtrong heat together with ſome inflammable ſubſtance in cloſe veſſels.

In the crucible uſed for the preparation of flowers of zinc, a conſiderable quantity of theſe flowers is found fixed to its ſides, and to the ſurface of the zinc, if any remains unburnt. Theſe latter flowers are much leſs white and light than the former. They have been produced by the part of the zinc which burnt leſs vehemently than the reſt. Their color is greyiſh, from a certain quantity of phlogiſton which they retain.

Flowers of zinc alſo are obtained from furnaces in which minerals containing zinc are ſmelted, particularly that of Rammelſberg. They adhere in great quantities to the upper part of the internal ſurface of the walls of the furnaces. But as theſe flowers ſuſtain a great heat, they are half fuſed and agglutinated together, forming maſſes, which muſt be taken off frequently in order to clear the furnaces. Flowers of zinc in this ſtate are called *cadmia fornacum*, or *pompholix.* *See* CADMIA *and* ZINC.

CCCX. FLOWERS of VEGETABLES. (e).

(e) FLOWERS. In this article, which is extracted from Dr. Lewis's notes on Neuman's Chemiſtry, the *colors* only of flowers ſhall be conſidered. Very few of the colors of flowers of vegetables are durable, or can be made durable by any means known. The only permanent color is *yellow*. The *red*, the *blue*, the *purple*, the *crimſon*, and the *violet* are very periſhable. Many flowers loſe theſe colors more by being dried, eſpecially by being ſlowly dried in a ſhady and not warm place. The colors of all of them periſh by keeping, even in the cloſeſt veſſels. The more haſtily they are dried, and the more perfectly they are ſecured from air, the longer they retain their beauty. The coloring matter of flowers extracted and applied on other bodies is ſtill more periſhable.

BLUE FLOWERS. The [illegible] of many blue flowers is extracted by infuſion in water [illegible] others, water acquires only [illegible] been [illegible] blue color to ſpirit [illegible] gave [illegible] of theſe [illegible] blue juices [illegible] acids; [illegible] by [illegible] the [illegible] from [illegible] alkaline liquors [illegible] flowers [illegible] kept

CCCXI. FLUIDITY. Fluidity is the ſtate of a body whoſe integrant parts are ſo diſunited and incoherent, that no ſenſible reſiſtance is oppoſed to their ſeparation in any direction; but which are nevertheleſs ſufficiently attracted by each other, to remain adjacent, and to form an aggregate body.

Hence fluidity is a middle ſtate betwixt hardneſs, in which the integrant parts of bodies adhere together firmly, and the entire want of aggregation, in which the integrant parts of bodies are ſo ſeparated and removed from each other, that their mutual attraction is no longer ſenſible.

kept till their colors are loſt, their infuſions acquire a red color from acids, and a green color from alkalis, but in a leſs degree than when the flowers were freſh. The red color produced by acids is ſcarcely more durable than the original blue: applied upon other bodies, and expoſed to air, it gradually degenerates into a faint purple, and at laſt diſappears, without leaving any ſtain behind. The green produced by alkalis changes to a yellow, which does not fade ſo ſoon. The green made by lime-water is more permanent and beautiful. Green lakes, prepared from blue flowers by means of lime-water, have been uſed by painters. The flowers of cyanus have been much commended for affording elegant and blue pigments. But Dr. Lewis has not been able to extract from them any blue color. They retain their color, when haſtily dried, longer than other blue flowers, but do not communicate their original color to any menſtruum.

RED FLOWERS readily communicate their color to water; and thoſe of a full red color give to a [illegible] ſpirit alſo a deep red tincture, [illegible] though ſomewhat paler than the watery infuſion. But the lighter red flowers, and thoſe which are purpliſh, impart little color to pure ſpirit. The color of infuſions of theſe flowers is diſpoſed to be heightened by acids, and to be changed to green by alkalis; [illegible] is not univerſal. For [illegible] the roſe color [illegible] were [illegible] by [illegible] flowers [illegible] full deep [illegible] of red [illegible] a green [illegible] [illegible] ing them deeper. Woods in [illegible]

nated with a ſolution of alum and of tartar, receives, on being boiled with the watery infuſion or decoction, a durable yellow dye. A durable yellow lake is prepared by precipitating with alum an infuſion of yellow flowers made in an alkaline ley. In ſome of the *orange-colored flowers* the yellow matter ſeems to be of the ſame kind as that of the pure yellow flowers; but the red matter ſeems to be different from that of the pure red flowers. The yellow matter is extracted from theſe flowers by water; and the remaining red matter is extracted by ſpirit of wine, or by a weak ſolution of fixed alkali in water. Such are the ſaffron-colored flowers of *Carthamus*. Theſe flowers, after the yellow matter has been extracted by water, are ſaid to give a red tincture to ley, from which a deep red fecula ſubſides, called *Safflower*, *Spaniſh red*, and *China-lake*. This pigment gives a beautiful red color to ſpirit of wine, but none to water. The yellow farina or fine duſt, reſting on the tips of the ſtamina of flowers, gives a fine bright yellow color to ſpirit of wine, and a duller yellow color to water. The colors of both the watery and ſpirituous tinctures were heightened by alkalis, rendered red by acids, and again reſtored to yellow by adding an alkali. This is the only known inſtance of the yellow color of a vegetable being rendered red by acids.

WHITE FLOWERS, or their expreſſed juices, impart a green color to alkaline leys, but have not been obſerved by Dr. Lewis to give a red color to acids. The white flowers of the common wild *convolvulus* give a deep yellow or orange color to water, which is weakened by acids, by alkalis, and by alum, as the infuſions of yellow flowers are. The [illegible] of *Xeranthemum* give a beautiful yellow color to water acidulated with ſpirit of nitre.

A body may be fluid in two manners; firſt, by the figure of its primitive integrant parts, ſo that each of theſe parts ſhall not touch any other but in one point, or in one infinitely ſmall ſide, and conſequently have but little or no adheſion. Such a body muſt neceſſarily and naturally be fluid. Fire ſeems to be the only body poſſeſſed of this eſſential fluidity.

The ſecond manner by which a body may be rendered fluid is, to leſſen the contact of the integrant parts, to disjoin them, or even to ſeparate them from each other by the interpoſition of a fluid. All bodies, which can only be fluid in this manner, are evidently not eſſentially fluid. On the contrary, they are naturally more or leſs hard and ſolid, and can only have a mediate or ſecondary fluidity. Such all bodies in nature appear to be, excepting fire. Hence, without fire no fluid would exiſt; all bodies would cohere together, and form a ſingle, ſolid maſs; and hence fire is the principle of all fluidity. But when a body is rendered fluid by fire, it may then be capable of giving fluidity to other bodies. Water, for inſtance, the fluidity of which is certainly cauſed by fire, may by interpoſing itſelf betwixt the integrant parts of gums and ſalts, give to them a fluidity ſimilar in ſome reſpects to its own.

We muſt not confound the fluidity received directly from fire with the fluidity received from bodies rendered fluid by fire. Some ſubſtances are incapable of receiving fluidity directly from fire, but only through the intervention of ſome other ſubſtance previouſly rendered fluid by fire. Such are gums, which are rather decompoſed than rendered fluid by fire, but which are readily ſoluble in water. Other bodies may be either rendered fluid directly by fire, or ſecondarily through the intervention of another body previouſly rendered fluid by fire. Such, for inſtance, are ſalts. They become fluid when expoſed alone to the action of fire, and are alſo capable of liquefaction by water.

The principal difference betwixt a body rendered fluid merely by the action of fire, and another body rendered fluid by the interpoſition of a fluid ſubſtance, is, that the integrant parts of the latter body adhere to thoſe of the interpoſed ſubſtance; and that this adheſion or affinity is the cauſe of the fluidity of that body.

This ſecondary fluidity, therefore, given by interpoſition of a fluid ſubſtance, is nothing elſe than a ſolution. The fluidity given immediately by fire is called by chemiſts, *fuſion*; we therefore ſay that a ſalt is diſſolved in water, but not fuſed or melted. This latter expreſſion is frequently uſed, though very improperly.

Theſe evident and important differences betwixt the fluidity of fire, which is eſſentially fluid, the fluidity of bodies fuſed merely by the action of fire, and the fluidity of bodies rendered fluid by the interpoſition of others, [illegible] fuſed, require that theſe different kinds of fluidity ſhould be diſtinguiſhed by names appropriated to each. We poſſeſs no ſuch preciſe expreſſions [illegible] been uſed to denote them. Bodies habitually fuſed might be called [illegible], and thoſe which have only a ſecondary fluidity might be called [illegible] given to the primary and eſſential fluidity of fire.

This want of ſuitable expreſſions ſhews the little attention given by chemiſts and natural philoſophers to fluidity, and to the properties of bodies by which they give and receive fluidity. [illegible] the properties of fire, and upon the effects which it produces upon other bodies, we have conſidered thoſe ſubſtances as having an independent fluidity, which we have generally ſeen in a fluid or fuſed ſtate; ſuch as air, ethereal ſpirits, mercury, ſpirit of wine, and even water and oils; although we frequently ſee theſe two laſt mentioned ſubſtances become ſolid by cold, or want of active fire. The fixation of mercury by a ſufficient degree of cold, the poſſibility of which is ſuſpected in the *Elements of the Theory of Chemiſtry*, and is aſcertained by experiments of ſome members of the Academy at Peterſburg, induces us to conjecture, that every body is naturally ſolid or hard; and that all fluid bodies receive their fluidity from fire, which is the only ſubſtance eſſentially fluid.

However that may be, this is evident, that as the aggregation of every body which is fluid or liquid muſt be broken, or much diminiſhed, fluidity is the moſt favorable ſtate for the formation of new unions; and that every ſubſtance which forms a new combination muſt neceſſarily have or acquire this ſtate. Therefore a preciſe and extenſive knowledge concerning fluidity, and the properties of bodies by which they give and receive fluidity, is exceedingly important in chemiſtry. *See* AGGREGATION, SOLUTION, FIRE, FUSION, *and* LIQUEFACTION.

CCCXII. FLUOR. This word, uſed as an adjective, is applied to ſignify the habitual fluidity of any ſubſtance, or that property by which a ſubſtance cannot be rendered ſolid, and is employed as an epithet to diſtinguiſh ſuch ſubſtances from others of the ſame kind, but which are habitually ſolid, or which may be rendered ſolid. Acids, for inſtance, which are habitually fluid, as all the mineral and ſome vegetable acids, are called *fluor acids*, in order to diſtinguiſh them from the acid of tartar and acid eſſential ſalts, which are naturally concrete. Alſo volatile alkali treated with quicklime, or with metallic earths, ſo that it is always liquid and not cryſtallized, is called *fluor volatile alkali*, to diſtinguiſh it from the concrete and cryſtallizable volatile alkali.

By *fluor*, uſed ſubſtantively, is meant a certain kind of ſtone which is fuſible, or which facilitates fuſion. Such are the greateſt part of *ſpars*, which are called fluors. Thus, for example, in ſpeaking of a white or colored ſpar, which is found in the matrix of an ore, we ſay that this matrix is mixed with a white, green, or yellow fluor. *See* SPAR. (f)

(f) FLUORS. Mineralogiſts differ very much [illegible]; ſome giving the name [illegible] red quartz cryſtals, called alſo falſe [illegible], falſe rubies, &c. *See* CRYSTALS [illegible] leſs tranſparent [illegible] all ſtones poſſeſſing the following properties may be properly referred, whether they be tranſparent or opake, colored or not colored, cryſtallized or poſſeſſing no determinate form.

1. They are not ſufficiently hard to ſtrike fire with ſteel. By this property the colored quartz cryſtals are excluded.

2. They are not ſoluble by acids.

3. They have not the diſtinguiſhing properties of gypſeous or of argillaceous earths.

4. They are fuſible by fire without addition. Pott, Cronſtedt, and others ſay, that they are not fuſible; but Mr. Engelſtom, the Tranſlator of Cronſtedt's Mineralogy, affirms, that he has fuſed all the fluors which he has tried by means of a blow-pipe; and Mr. D'Arcet found, by his experiments,

that

CCCXIII. FLUX. This word is ſometimes uſed ſynonimouſly with *fuſion.* For inſtance, an ore, or other matter, is ſaid to be in liquid flux, when it is completely fuſed.

But the word flux is generally uſed to ſignify certain ſaline matters, which facilitate the fuſion of ores, and other matters which are difficultly fuſible, in eſſays and reductions of ores. Fixed alkalis, nitre, borax, tartar, and common ſalt, are the ſaline matters of which fluxes are generally compoſed. But the word *flux* is more particularly applied to mixtures of different proportions of only nitre and tartar; and theſe fluxes are called by particular names, according to the proportions of theſe ingredients, as we ſhall ſee in the following articles.

CCCXIV. FLUX (WHITE). White flux is made with equal parts of nitre and of tartar detonated together, by which they are alkaliſed. The reſiduum of this detonation is an alkali compoſed of the alkalis of the nitre and of the tartar, both which are abſolutely of the ſame nature. As the proportion of nitre in this mixture is more than is ſufficient to conſume entirely all the inflammable matter of the tartar, the alkali remaining after the detonation is perfectly white, and is therefore called *white flux*; and as this alkali is made very quickly, it is alſo called *extemporaneous alkali*. When a ſmall quantity only of white flux is made, as a few ounces, for inſtance, ſome nitre always remains undecompoſed, and a little of the inflammable principle of the tartar, which gives a red or even a black color to ſome part of the flux; but this does not happen when a large quantity is made of white flux, becauſe then the heat is much greater. This ſmall quantity of undecompoſed nitre and tartar which remains in white flux is not hurtful in moſt of the metallic fuſions in which this flux is employed: but if the flux be required perfectly pure, it might eaſily be diſengaged from thoſe extraneous matters by a long and ſtrong calcination, without fuſion. *See* CALCINATION.

CCCXV. FLUX (CRUDE). By crude flux is meant the mixture of nitre and tartar in any proportions, without detonation. Thus the mixture of equal parts of the two ſalts uſed in the preparation of the white flux, or the mixture of one part of nitre and two parts of tartar for the preparation of the black flux, are each of them a crude flux before detonation. It has alſo been called *white flux*, from its color; but this might occaſion it to be confounded with the white flux above deſcribed. The name therefore of crude flux is more convenient.

that they were fuſible. I have alſo, by a very conſiderable heat, fuſed ſome of thoſe white opake fluors, which are ſaid to be ſimilar to the *petunſe*, or one of the materials of which the Chineſe compoſe their porcelain.

5. With much more moderate heat they greatly facilitate the fuſion of calcareous and argillaceous earths, and of the topaz, according to Mr. Pott. For which quality they have been much employed in the ſmelting of ores, as they promote the fuſion of the adhering earths.

6. When heated [illegible] they [illegible] being [illegible] [illegible] ſays, [illegible] has [illegible] ſmall portion of [illegible]

Crude flux is detonated and alkaliſed during the reductions and fuſions in which it is employed, and is then changed into white or black flux, according to the proportions of which it is compoſed. This detonation produces good effects in theſe fuſions and reductions, if the ſwelling and extravaſation of the detonating matters be guarded againſt. Accordingly, crude flux may be employed ſucceſsfully in many operations; as, for inſtance, in the ordinary operation for procuring the regulus of antimony.

CCCXVI. FLUX (BLACK *or* REDUCING). Black flux is produced from the mixture of two parts of tartar and one part of nitre detonated together. As the quantity of nitre which enters into the compoſition of this flux is not ſufficient to conſume all the inflammable matter of the tartar, the alkali which remains after the detonation contains much black matter, of the nature of coal, and is therefore called *black flux*.

This flux is deſignedly ſo prepared, that it ſhall contain a certain quantity of inflammable matter; for it is thereby capable not only of facilitating the fuſion of metallic earths like the white flux, but alſo of reviving theſe metals by its phlogiſton. From this property it is alſo called reducing flux; the black flux, therefore, or crude flux made with ſuch proportions of the ingredients as to be convertible into black flux, ought always to be uſed when metallic matters are at once to be fuſed and reduced, or even when deſtructible metals are to be fuſed, as theſe require a continual ſupply of phlogiſton to prevent their calcination. *See* NITRE, REDUCTION, *and* TARTAR.

CCCXVII. FORGE. An ordinary forge is nothing but a pair of bellows, the nozzle of which is directed upon a ſmooth area, on which coals are placed. The nozzle of a pair of bellows may be alſo directed to the bottom of any furnace, to excite the combuſtion of the coals placed there, by which a kind of forge is formed. In laboratories, there is generally a ſmall furnace conſiſting of one cylindrical piece, open at top, which has at its lower ſide a hole for receiving the nozzle of a double bellows. This kind of forge-furnace is very convenient for fuſions, as the operation is quickly performed, and with few coals. In its lower part, two inches below the hole for receiving the nozzle of the bellows, may be placed an iron plate of the ſame diameter, ſupported upon two horizontal bars, and pierced near its circumference with four holes diametrically oppoſite to each other. By this diſpoſition, the wind of the bellows, puſhed forcibly under this plate, enters at theſe four holes; and thus the heat of the fire is equally diſtributed, and the crucible in the furnace is equally ſurrounded by it. This contrivance is uſed in the forge-furnaces for melting copper, with this difference only, that theſe furnaces are ſquare, which is a matter of no conſequence.

As the wind of bellows ſtrongly and rapidly excites the action of the fire, a forge is very convenient when a great heat is to be applied quickly; but it is not ſuitable when the heat is to be gradually encreaſed.

The forge, or blaſt of bellows, is uſed in ſeveral operations in ſmall; as, to fuſe [illegible], &c. It is alſo much uſed in works in the great, which require a ſtrong heat, without much management, and chiefly in the ſmelting of ores, and fuſion of metallic matters.

CCCXVIII. FRITT. Fritt is a mixture of ſeveral ſubſtances intended to be fuſed together for the purpoſe of making glaſs. After theſe ſubſtances have been mixed together, they are generally expoſed during a certain time to a more or leſs ſtrong heat, which is, however, incapable of compleatly fuſing them. The intention of this operation is either to effect a ſlight union betwixt theſe matters, or to free them more perfectly from any inflammable or extraneous matter, by this calcination. *See* VITRIFICATION.

CCCXIX. FRUITS. (g)

CCCXX. FULIGINOSITY. By this word is meant ſoot, or the black matter which accompanies the flame of oils and of oily ſubſtances. *See* SOOT.

CCCXXI. FULMINATION. Fulmination is the ſudden and violent exploſion and inflammation of certain bodies, which are therefore called *fulminating*. Such are the exploſions of fulminating powder and of fulminating gold. The exploſion of theſe matters is called *fulmination*, from the noiſe accompanying it, by which it reſembles thunder.

CCCXXII. FURNACE. Furnaces are chemical inſtruments uſed for containing combuſtible matters, by the burning of which the heat requiſite for operations is procured; and alſo for containing the ſubſtances themſelves to which the heat ought to be applied.

As chemiſts require for different operations all the poſſible degrees of heat, from the weakeſt to the ſtrongeſt, and as the form of furnaces contributes greatly, as we ſhall ſee, to produce the different degrees of heat; they have contrived many furnaces of different forms and conſtructions; but all theſe furnaces may be reduced to a ſmall number of general diſpoſitions, which we ſhall now deſcribe.

(g) FRUITS are conſidered only as *coloring materials* in this article, the greateſt part of which is extracted from a note of Dr. Lewis to his Tranſlation of Neuman. The red juices of fruits, as of *currants, mulberries, elder berries, morello and black cherries*, when inſpiſſated and dried, may be again diſſolved in water, to which they give nearly the ſame red color as they do when freſh. Rectified ſpirit extracts the tinging particles, and acquires a brighter color than the watery ſolution; becauſe much of the mucilage is left undiſſolved by the former. The red ſolutions and the juices are ſometimes made dull, and ſometimes more florid, by acids, and are generally rendered purpliſh by alkalis. The colors of theſe juices are generally periſhable. They are not deſtructible by the fermentation of the liquors, but they quickly decay when the juice is ſpread thinly on any ſubſtance, and dried in open air. The bright lively reds are ſooneſt changed. The dark, dull red ſtain of the black cherry is conſiderably durable. The bright red fruit of the *opuntia or prickly pear* is an exception to the above rule; as it gives, according to Labat, a beautiful red dye. The ripe berries of *buckthorn* ſtain paper of a green color. From theſe is prepared the ſubſtance called *ſap-green*, which is a pigment ſufficiently durable, ſoluble in water, but not miſcible with oil. The ſame berries dried whilſt green, and macerated in alum-water, are ſaid to yield a yellow pigment; and when they have grown over-ripe, a purple pigment. Woollen cloth, prepared with alum and tartar, receives, on being boiled with the berries, a periſhable yellow dye. The *French berries*, or *graine d'Avignon*, one of the moſt periſhable yellow dyes, is a berry of the ſpecies of buckthorn. It is ſaid, that the berry of the *heliotropium tricoccum* ſtains paper of a green color; and that this green is ſoon changed to a blue; that the common blue paper receives its color from this juice; and that the red rags called *turnſol*, employed for coloring wines and other liquors, are tinctured by the ſame juice turned red by acids. Mr. Niſſole ſays, that the coloring juice is obtained, not from the berries, but from the tops of the plant. The Dutch are ſaid to prepare their rags from other materials, of which archil is a principal one.

The ſeeds of ſome plants, as of peony, are covered with a fine ſhining red membrane. The pellicles of the ſeeds of an American tree afford the red maſs called *arnotto, orlean*, and *roucou*. *See* ARNOTTO.

The *ſimple furnace* is a kind of hollow tower, cylindrical or priſmatical, wit two doors or principal openings; the one below, called the *door of the aſh-hole*; and the other immediately above this, called the *door of the fire-place*. Betwixt theſe two doors a grate is placed horizontally acroſs the interior part of the furnace, dividing the whole cavity of the furnace into two parts: the lower part is called the *aſh-hole*, becauſe it receives the aſhes which fall from the fire-place. The door of the aſh-hole gives admittance to the air neceſſary for maintaining the fire within the furnace. The upper cavity of the furnace is called the *fire-place*, becauſe it contains the combuſtible matters. Through the door of the fire-place, freſh fuel is to be introduced, to ſupply the place of what is conſumed.

This ſimple furnace, ſimilar to that uſed in kitchens, is ſufficient for many chemical operations. In the fire-place, amidſt the coals, crucibles may be placed for the fuſion of fuſible matters; ſuch as lead, tin, biſmuth, &c. or for the calcination of matters which require but little heat for their calcination; ſuch as the alkali for making Pruſſian blue, bezoar mineral, &c.

On this furnace may alſo be placed baſons for evaporations, alembics for diſtilling in the water-bath, pots filled with ſand for digeſtions and diſtillations to be performed by means of a ſand-bath and a gentle heat, either with alembics or with retorts.

As ſeveral of the operations made with this furnace are of long duration, and as the furnace requires a continual ſupply of fuel; chemiſts have contrived to adapt to it a magazine of coals in form of a hollow tower, cloſed in its upper part, and ſo diſpoſed, that while the coal of the fire-place is conſumed, that of the tower falls down and ſupplies its place. The furnace thus diſpoſed is called an *athanor*, or the *furnace of ſluggards*. *See* Athanor. *See* Plates.

The *lamp-furnace* is a kind of athanor, in which the heat is produced and maintained by the flame of a lamp introduced within it. This furnace has evidently no occaſion for an aſh-hole, a grate, or a fire-place. It has only one opening below, through which the lamp is introduced, and a kind of ſmall chimney made in its upper and lateral part, for circulation of air, to keep up the flame of the lamp, and to give vent to the ſmoke. This furnace is very convenient for diſtillations which require little heat. A water-bath or ſand-bath may be fitted to it. It is particularly uſeful for digeſtions. *See* Plates.

The *reverberatory furnace* is the ſimple furnace, the fire-place of which is covered with a piece of the ſame diameter and form as the furnace, which is generally cylindrical. This piece is croſſed in its lower part by two bars of iron placed horizontally and parallel to each other, and at its upper edge it has a ſemi-circular cut. This piece conſequently forms a third cavity, which is called the *Laboratory*, becauſe it is intended to receive the retorts containing the matter to be diſtilled. The ſemi-circular cut is made to give paſſage to the neck of the retort, which, as we have ſaid under the article Distillation, ought to be inclined at an angle of 45 degrees. The uſe of the two bars at the bottom of the laboratory is to ſupport the veſſel placed there.

Above the piece we have now deſcribed is a fourth piece placed, the form of which is that of a ſpherical cap, or of an inverted dome: it is accordingly called the *dome.* This dome has an equal diameter to the other piece, to which it is to be fitted; and in its lower edge it has a ſemi-circular cut, which correſponds with the ſimilar cut of the lower piece; and theſe together form a circular opening: the dome has in its top another opening or ſhort tube, through which the air contained in the furnace paſſes, and is a kind of chimney.

The uſe of the dome is to keep up the heat all around the retort which is placed in the furnace, and to apply a certain degree of heat to the upper part or vault of the retort, by reflecting or reverberating it: hence it is called a *reverberatory.* By this diſpoſition the vapors which riſe in the retort are determined more efficaciouſly to paſs through its neck. We may judge after this deſcription, that reverberatory furnaces are only uſed for diſtillations with a retort, in which a certain degree of heat is neceſſary.

Diſtillation may be performed in reverberatory furnaces, either in naked fire, by placing the retort immediately upon the bars, or in a ſand-bath, by placing upon theſe ſame bars an iron veſſel, in the upper edge of which is a ſemi-circular cut. Into this iron veſſel is put fine ſand to the thickneſs of one or two fingers: then the retort is to be placed in it; and, laſtly, it is to be filled with ſand up to the arch of the retort. If the heat be required to be of a certain ſtrength, the iron veſſel muſt have a diameter ſo much leſs than the internal part of the furnace, that an empty ſpace of about the thickneſs of a finger ſhall be left betwixt them, excepting on the ſide where the neck of the retort is; and there the hollow cuts of the furnace and iron veſſel that correſpond to each other ought to join exactly. *See* PLATES.

The *melting furnace*, or wind furnace, is intended to produce the greateſt degree of heat that can be excited without bellows. This furnace ought to be ſo conſtructed, that a current of air ſhall conſtantly paſs through the fire-place; and the more ſtrongly and rapidly this air paſſes, the more intenſe will be the heat in the furnace.

The chief method for producing this effect is to leave in the upper part of the furnace a ſpace cloſe on every ſide, excepting above and below; becauſe the air contained in this cavity being rarefied and expelled by the heat produced by the fuel burning in the furnace, a vacuum is here formed, which the external air neceſſarily tends to occupy from its gravity.

This being eſtabliſhed, the furnace ought evidently to be ſo diſpoſed that the external air ſhall be obliged to enter at the aſh-hole, and to paſs through the fire-place, to fill the vacuum which is continually forming both in the internal part of the furnace and in its upper cavity.

We ought to obſerve, that the column of air which correſponds with the upper part of the furnace, being a little ſhorter, and conſequently lighter, than the column which correſponds with the lower part, the air appears naturally determined to enter at the bottom, and to go out at the the top of the furnace; ſo that if this furnace was a hollow cylinder, the lower and upper mouths of which were equal, and if the fire-place was in the middle, the air would probably paſs through it from bottom to top; but this difference of the two columns being almoſt infinitely ſmall, the velocity of the current of air would be as ſmall: but if, inſtead of this diſpoſition, the furnace be contracted in its upper part, and if it be made to become a tube of leſs diameter, then the rarefied air is obliged conſiderably to accelerate its courſe in paſſing through a ſtraiter ſpace and thereby overcomes more eaſily the preſſure of the ſuperior air: hence the air introduced through the lower part of the furnace, in order to fill the vacuum which is continually forming in its upper part, paſſes ſo much more rapidly through the fire-place as it finds leſs obſtacle above; and conſequently this diſpoſition of the furnace neceſſarily determines a ſtrong and rapid current of air to paſs through it, from the bottom to the top.

From what has been ſaid we may eaſily perceive, that the more the ſpace or air is rarefied in the upper part of the melting furnace, the ſtronger and more rapid is the external current of air which is obliged to enter the furnace to fill up this vacuum; and conſequently the more intenſely the coals muſt burn. Hence theſe furnaces produce ſo much more heat, as the tube which is at their upper part, called the *tube of aſpiration*, is longer. But we muſt obſerve, that although the activity of this furnace is owing in great meaſure to the contraction in its upper part or to its tube; nevertheleſs a too great contraction of the tube would be very inconvenient, becauſe the air rarefied, and obliged to go out at the upper part, can only acquire a certain determinate velocity: whence it follows, that if this tube, through which the rarefied air is to go out, were ſo ſtrait that this air could not paſs, unleſs it had a greater velocity than it is capable of acquiring, then the air, finding an obſtacle in its way, would be retarded in its progreſs; and conſequently too great ſtraitneſs in the tube impedes rather than facilitates the courſe of the air: accordingly, I have found by experience, that a melting furnace to which too ſtrait a tube, however long, has been adapted, produces little effect, compared with that cauſed by a tube of ſufficient diameter.

Hence the diameter of the tube muſt have a certain relation to the capacity of the furnace, and to the door of the aſh-hole. I have found that the diameter of the tube ought to be to the diameter of the furnace as 2 to 3 nearly, particularly when the tube is long enough (b). The opening at the bottom of the furnace may be equal in width to the body of the furnace, or it may be contracted, if the air be required to ſtrike the fire with more force and rapidity. After all theſe principles, we now proceed to the conſtruction of a good melting furnace. The body of this furnace does not differ from that of a ſimple furnace, except that it is, or may be open, or almoſt

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“(b) The diameter of the tube ought to have a certain proportion, not to the door of the aſh-hole, but to the ſpace left by the intervals of the grate; and both theſe ought to bear a certain proportion to the diameter of the fire-place. The proportion mentioned by the Author, which the diameter of the tube ſhould hold to the diameter of the fire-place, as two to three, ſeems to allow too great a width to the tube. When the tube is too wide, more air paſſes through the furnace than is neceſſary for the maintenance of the fire and conſumption of the fuel; by which means the furnace is greatly cooled; and even, if the air ſhould be prevented from paſſing through in too large a quantity, by narrowing the door of the aſh-hole, the air will paſs down the wide tube, which will then contain two diſtinct columns of air, one aſcending, and the other deſcending. The following proportions ſeem to me to be preferable: If the area of the fire-place contain 144 ſquare inches, let the area of the tube, and the ſum of the ſeveral intervals of the grate be, each of them, 36 ſquare inches: but in certain ſtates of the fire, for inſtance, when it is thoroughly kindled, the upper vent may be advantageouſly ſtill further contracted by regiſters, by which much fuel may be ſaved, and the fire kept more equally intenſe.

entirely open, below, and ſupported upon feet, or a kind of tripod, which ſerves as an aſh-hole. An elliptical form is generally given to it, with intention to concentrate the heat *(i)*. The upper part of this furnace is terminated by a dome higher than that of the reverberatory furnace, called the *cap*. This cap has two openings, one of which is placed laterally and in the front; it ought to be large, and to be capable of being cloſely ſhut by a door: the other is at the top, and ought to be a tube of a convenient diameter, upon which other tubes of indeterminate length are adjuſted.

This furnace has no laboratory, or rather its laboratory is the fire-place itſelf; for the matters to which the heat is to be applied are placed in the fire-place, and ſurrounded by the burning coals.

The melting furnace may have a door to the fire-place; but this door ought to be kept ſhut during the operations. It only ſerves for the more convenient examination of the condition of the crucibles or other matters placed in the furnace, and not for the introduction of freſh fuel, for which purpoſe the door of the cap is intended. This latter door ought to be very large, that a conſiderable quantity of coal may be thrown in at once. The reaſon why this door is preferable to the door of the fire-place for the introduction of the fuel is, that the current of air may not be diſturbed in its direction; and therefore the lateral door ought to be kept open as little as poſſible.

When the internal diameter of ſuch a furnace is 12 or 15 inches, when the diameter of the tube is 8 or 9 inches, and its height 18 or 20 feet, and when the furnace is well ſupplied with fuel, an extreme heat is produced: in leſs than an hour the fire will be white and dazzling, like the ſun: its heat will be equal to the ſtrongeſt degree of heat in a glaſs-houſe furnace. In leſs than two hours may be melted whatever is fuſible in furnaces *(k)*. The hotteſt part of this furnace is 4 or 6 inches above the grate.

Chemiſts generally believe that the power of a melting furnace is greatly encreaſed by a wide and high aſh-hole, or by bringing the air which is to enter it through a long pipe from without the houſe in which the furnace ſtands: but theſe advantages are either imaginary, or only relative to the vacuum formed in the upper part of the furnace. If indeed a furnace be ſo placed that the opening of its aſh-hole ſhall be fitted to the mouth of a great cavity; as to a cave, for inſtance, in the roof of which a hole is made, into which this furnace is to be fitted; and if this cave has no other opening than through the bottom of the furnace; then a very ſtrong current of air will paſs from the cave acroſs the furnace, although the furnace had neither cap nor tube: but we muſt obſerve, that this current of air will always be ſtronger if the furnace is provided with a dome and tube; and ſecondly, if the air be determined to paſs from the cave acroſs the furnace, even without dome or tube, this muſt proceed

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(i) The inequality of the ſurface of the ſides of the furnace would prevent any advantage from the elliptical form of furnaces, even if heat were ſuppoſed to diffuſe itſelf, like light, only in right lines, and to be thereby capable of concentration by reflexion; a ſuppoſition, however, which cannot be admitted.

(k) Moſt fuſible ſubſtances may be fuſed in a much leſs time: nevertheleſs we find from M. D'Arcet's Memoir concerning the effects of a violent and long-continued heat, that by prolonging the action of fire, he had been able to vitrify ſubſtances which had reſiſted the moſt violent fires continued only during a ſhorter time.

only from the heat of the furnace rarefying the ambient air, by which the more condenſed air of the cave is determined to paſs through the furnace to ſupply the place of this rarefied air. In this caſe, the chamber in which the furnace is placed, ſerves inſtead of the dome and tube. This happens in a glaſs-houſe furnace. Theſe furnaces are built upon ſubterranean vaults, which ſerve as aſh-holes. The internal capacity of theſe furnaces is very great, and is occupied only partly by the combuſtible matters, and by the pots containing the glaſs: hence the air of the aſh-hole is continually introduced there to fill this empty ſpace: beſides, the heat is always very great in the domes under which the furnaces are built; the contained air is therefore continually rarefied; ſo that they ſerve as the domes and tubes of furnaces to draw the air from the vaults.

The pipe which is ſometimes fitted to the aſh-hole of melting furnaces does not contribute to the draught of the furnace, excepting the laboratory in which the furnace ſtands be ſmall and confined: for then the air of this laboratory, being ſoon heated and rarefied, becomes leſs proper for exciting fire than the colder external air which the pipe ſupplies. *See* Plates.

The furnace called the *eſſay* or *cupelling furnace* is of a priſmatic quadrangular figure, and is chiefly uſed to make eſſays of the value of ſilver, or of ſilver ores. This furnace is compoſed of an aſh-hole, a fire-place, and an upper part which terminates it above, like a quadrangular truncated pyramid. The fire-place and aſh-hole are not, properly ſpeaking, ſeparated from each other, becauſe this furnace has no grate (*l*); hence the coals in this furnace fall to the bottom: in the lower part of the furnace are three ſmall doors, two in the ſides, and one in the front: above this latter door is a fourth door, placed like that of the fire-place of a ſimple furnace; and at the bottom of this door are two iron bars, placed within the furnace horizontally and parallel to each other. Theſe bars are intended to ſupport a muffle, the mouth of which correſponds exactly to the laſt mentioned door. In this muffle the cupels and veſſels capable of containing the matter to be heated are to be placed.

The top of this furnace is truncated, and forms a pretty large aperture, through which the fuel is to be introduced. Some of theſe furnaces have a ſmall hole in the front of this upper part, through which an iron rod is introduced to puſh the coals down, and which alſo ſerves to ſhew the ſtate of the fire. In ſome of theſe furnaces the upper part is terminated by a ſhort tube, which on ſome occaſions is convenient; for although the internal capacity of this furnace, including its upper part, makes a ſufficient draught for theſe operations, a greater heat may poſſibly be required, and this is effected by adapting a tube to this furnace. *See* Essays.

Some operations, which muſt be made either in a muffle or in a reverberatory furnace, require the ſtrongeſt melting heat. The diſtillation of Kunckel's phoſphorus, for inſtance, requires a heat much ſuperior to that of ordinary diſtillations. Eſſays alſo of porcelain and vitrification, which ought to be done very cleanly, and therefore under a muffle, require a very violent heat, which cannot be procured in an ordinary eſſay furnace. In theſe caſes a tube may be fitted to the diſtilling

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(*l*) A grate would certainly render this furnace much more convenient; in the plate therefore which we have added of this furnace a grate is repreſented.

or to the eſſay-furnaces, like that of the melting furnace; and thus as ſtrong a heat as is wanted may be procured. *See* PHOSPHORUS, PORCELAIN, VITRIFICATION. (*m*)

Chemiſts have contrived many other furnaces, and ſome very complicated, for particular purpoſes; but they are moſtly embarraſſing, ill-contrived, and even uſeleſs: for by the furnaces above deſcribed an able operator may perform perfectly well every chemical operation.

All theſe furnaces may be either portable, and compoſed of baked earth hooped with iron rings, or covered with iron plates, if they are intended to be more durable; or they may be fixed and ſtationary, and made of bricks and tiles. This depends on the ſize and diſpoſition of the laboratory.

The matter of all chemical furnaces is always a clay which ought to be of a good quality. Common clays do well enough for furnaces that are not intended to ſuſtain very violent heats, by which furnaces are apt to be cracked and deſtroyed, even before the operation is finiſhed, unleſs they are made of the moſt pure and refractory clay. *See the clays moſt proper for this purpoſe under the article* CLAY.

In theſe furnaces no iron bars or ſupports ought to be uſed, as that metal is very quickly melted, calcined, and deſtroyed. All the ſupports within theſe kinds of furnaces ought to be of the ſame clay of which the furnace conſiſts. As the heat is much leſs in the tube than in the body of the furnace, this tube is frequently made of iron plates, excepting its lower part, which ought always to be made of clay. Theſe tubes of iron plate have many advantages, as they are light and manageable; but they have a great inconvenience, which is, that their inner ſurfaces are ſubject to calcine; hence when much flame paſſes through them, ſcales fly off from the iron with noiſe; which falling upon the crucibles and muffles, diſpoſe them to vitrify, becauſe iron is a powerful flux to clay. The whole tube ought therefore to be made of clay.

When the tube is long, it ought to be ſtrengthened by iron rings and hooks; but theſe ought to be ſo arranged that the tube may be lengthened and ſhortened, according as the greater or leſs heat may diſpoſe it; otherwiſe it might crack.

The furnaces deſcribed in this article are employed, and are neceſſary, for the ſeveral operations of chemiſtry. Many of them are alſo uſed in the arts, in manufactures, and in works in the great: ſuch are the furnaces for glaſs, pottery, porcelain, and for ſmelting of ores. What is peculiar to any of theſe furnaces may be found under the article of the art in which it is employed. In other reſpects their ſtructure is conformable to the general principles eſtabliſhed in the preſent article. (*n*)

CCCXXIII. FUSIBILITY. Fuſibility is a quality which renders bodies ſuſceptible of becoming fluid, when expoſed to a certain degree of heat.

(*m*) See a plate and deſcription of a very commodious furnace for experiments on vitrification, and on the making of porcelain, and for many other purpoſes.

(*n*) *See* PLATES, where ſeveral furnaces are repreſented, and the deſcriptions annexed; in which the proper compoſitions for lining the inſides of furnaces made of plated iron, and the methods of applying them, are related.

Fuſibility is the reverſe of the refractory quality; ſo that the leſs the heat is which is requiſite for the fuſion of any ſubſtance, the more fuſible it is.

Bodies differ much from each other as to their degrees of fuſibility. Some of them, as air and mercury, are ſo fuſible that the heat of the atmoſphere is always ſufficient to keep them fluid; others, as ſome oils and water, which are naturally ſolid with the degree of cold marked 0 in Reaumur's thermometer, are preſently melted when they are expoſed to a greater heat: other ſubſtances again, as lead, tin, biſmuth, &c. are habitually ſolid in the greateſt natural heats; but are fuſible with a degree of heat leſs than is requiſite to make them red: and, laſtly, others are not fuſible till they become red, and even white, by heat: ſuch are ſilver, gold, copper, iron, glaſs, &c.

As the fuſion of a body is cauſed by the interpoſition of fire betwixt its integrant parts, by which their adheſion is deſtroyed, we cannot conceive any other cauſe of the greater or leſs fuſibility than a more or leſs intimate contact, and a more or leſs ſtrong adheſion of the integrant parts of different bodies; which are diſpoſitions depending on the figure of theſe parts. *See* HARDNESS *and* FLUIDITY.

CCCXXIV. FUSION. Fuſion is the ſtate of a body rendered fluid by fire. *See* FLUIDITY *and* FUSIBILITY.

G.

CCCXXV. GALANGAL. (o)

CCCXXVI. GALBANUM. (p)

CCCXXVII. GALLEY. This name is given to reverberatory furnaces, in which ſeveral retorts may be placed at the ſides of each other. As theſe furnaces are oblong, and have lateral openings, they have been ſuppoſed to reſemble galleys, and have thence received their name.

CCCXXVIII. GALENA. (q)

CCCXXIX. GALLS. (r)

(o) GALANGAL. The Indian root called *greater galangal* reſembles ginger in ſmell, taſte, and chemical compoſition. The *ſmaller galangal* has a ſtronger and more agreeable ſmell than the former, and a more pungent and hot taſte, like that of pepper. From 16 ounces of this root ſcarcely two ſcruples of oil were obtained; and this oil poſſeſſes little of the pungency of the root. Six ounces of extract were obtained by means of water from 16 ounces of the root; and an ounce and a half from the ſame quantity by means of ſpirit of wine. The watery extract was the more pungent of the two. *Neuman.*

(p) GALBANUM is a gum-reſin, containing more of a reſinous than gummy matter. Spirit of wine extracted from a pound of it nine ounces and a half, and water extracted from the ſame quantity only three ounces. The ſmell, flavor, and peculiar taſte of galbanum reſides in an eſſential oil, which may be raiſed in diſtillation either by means of water or of ſpirit of wine. From a pound of galbanum ſix drams of eſſential oil may be obtained. This oil, or a great part of it, is of a blue color, ſometimes of a deep bright blue. By expoſure to air this blue color is changed to a purple. *Neuman.*

(q) GALENA is the name of a lead ore, conſiſting of cubic particles, and compoſed of lead mineraliſed by ſulphur, with which alſo a little ſilver is almoſt always united. *See* ORES *of* LEAD.

(r) GALLS are excreſcencies found upon oak trees, and are amongſt the ſtrongeſt vegetable aſtringents. Extracts made from galls, either by water or by ſpirit, poſſeſs all the aſtringency of theſe vegetable ſubſtances. From ſixteen drams of galls fourteen drams were extracted by water; and from the ſame quantity twelve drams and two ſcruples were extracted by ſpirit. Galls, like other vegetable aſtringents, or the infuſions of theſe ſubſtances, being added to ſolutions of green vitriol, or to dilute and ſaturated ſolutions of iron in any acid, change the color of theſe ſolutions to a deep blue or black. The black liquor thus produced is the baſis of inks, and of many black dyes. *See* BLACK *and* INK. When the green vitriol is diſſolved, and when the galls are infuſed in diſtilled water, or in common ſpring waters, the color produced by mixing them is, according to Dr. Lewis, blue: but if the ſmalleſt portion of alkaline ſalt be diſſolved in the water, or if this water has any putrid tendency,

CCCXXX. GAMBOGE. (s)

CCCXXXI. GANGUE. Gangue is the matrix of ores. *See* MATRIX.

CCCXXXII. GARLIC. (t)

CCCXXXIII. GARNET. (u)

CCCXXXIV. GAS. This name is given by chemiſts to the volatile in-

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tendency, however ſmall, the color produced will be purpliſh or reddiſh. Theſe colors, when rendered more intenſe, by adding more of the coloring ſubſtances to the water, appear of a black color. The blackneſs produced by this mixture proceeds from a coloring matter which is only diffuſed through the liquor, and may be ſeparated from thence by dilution with water, and by depoſition. The ſeparation may be prevented, as is done in the preparation of ink, by adding ſome mucilaginous matter, as gum arabic. This coloring matter is evidently a ferruginous precipitate; for altho' it is not magnetical, it may be rendered magnetical by a ſlight calcination. To this precipitate ſome of the inflammable matter of the vegetable aſtringent adheres and gives color. When by calcination this adhering matter is made to combine in ſome meaſure with the ferruginous precipitate, this precipitate, though not perfectly metallized, is however ſufficiently metallized to be rendered magnetical. In theſe properties this precipitate correſponds with the blue ferruginous precipitate, which forms Pruſſian blue, to which alſo ſome phlogiſtic matter adheres and gives color; but it differs from Pruſſian blue by this property, that it is ſoluble by acids, whereas the latter precipitate is not ſoluble. Thus, the black coloring matter of inks may be diſſolved by acids, and their color thereby deſtroyed. Alkalis alſo deſtroy the blackneſs of inks, by diſſolving the aſtringent or inflammable adhering matter, and leaving the iron in an ochery ſtate, ſimilar to the precipitates of iron, formed by adding alkalis to ſolutions of that metal in acids. The blackneſs deſtroyed by adding acids to ink is recovered by addition of alkalis; and converſely.

I have not found that galls precipitate other metallic ſubſtances; but I have obſerved, that when added to metallic ſolutions, the precipitates afterwards formed from theſe by fixed alkalis, were deeply colored, and generally purple.

(s) GAMBOGE is an acrid gum-reſin, the gummy parts of which are ſo intimately blended with the reſinous, that greateſt part of it is ſoluble either by water or by ſpirit of wine. It forms a beautiful yellow pigment, and is much uſed as ſuch by painters. Dr. Lewis ſays, that it gives a beautiful and durable citron-yellow ſtain to marble, whether rubbed in ſubſtance on the hot ſtone, or applied, as Dragon's blood is, in form of a ſpirituous tincture. When it is applied on cold marble, the ſtone is afterwards to be heated, to make the color penetrate.

(t) GARLIC. The roots of garlic contain a conſiderable quantity of mucilage, ſome reſin, and a very ſmall portion of eſſential oil, in which the whole ſmell, taſte, and peculiar qualities of garlic reſide. From thirty-two ounces of garlic diſtilled with water, Neuman could obtain ſcarcely half a dram of this oil.

(u) GARNET, *Granatus gemma*, is a ſtone ranked amongſt thoſe called gems, tho' leſs brilliant than any other gem; it is tranſparent, ſometimes more and ſometimes leſs; generally of a dark-red color, but ſometimes yellowiſh or brown; the eighth ſtone in hardneſs from diamonds; and fuſible by fire. Cronſtedt forms a diſtinct order of the garnets and the baſaltes, which he calls *terræ granatæ*. The diſtinguiſhing property of theſe garnet earths is, that they are more fuſible in proportion as they contain leſs metallic matter, and are more tranſparent and glaſſy in their texture. In other reſpects they reſemble the ſiliceous order of earths. *See* BASALTES. All garnets contain iron; moſt of them contain tin alſo; and ſome, according to Mr. Swab, contain iron and lead. Their forms are various; ſome having ſix ſides, and others having a greater number. To imitate garnets Neri directs, that twenty pounds of cryſtal frit, ſixteen pounds of calx of lead, three ounces of manganeſe, half an ounce of zaffre, ſhould be fuſed together during twelve hours; and that the vitrified maſs, after it is ſeparated from any lead which may have been revived by the fuſion, muſt be again kept in fuſion during ten hours.

viſible parts which eſcape from certain bodies, and which cannot be retained and collected, at leaſt without great difficulty, and mixture of other ſubſtances.

Thus, for example, the noxious vapors which riſe from burning charcoal, and from matters undergoing the ſpirituous and putrid fermentations, the volatile part of ſpirituous mineral waters, the ſpiritus rector of ſome ſubſtances, ſuch as muſk, may be called the *gas* of theſe bodies.

The gas of moſt ſubſtances, particularly thoſe which affect the nerves, ſeems to be nothing but pure, or almoſt pure phlogiſton, which is diſengaged from bodies without ignition. The mineral noxious vapors called *damps* may be alſo ranked amongſt vapors called *gas*, at leaſt thoſe of them may which are inviſible. *See* DAMPS.

CCCXXXV. GELATINOUS, *and* GELLY. (x)

CCCXXXVI. GEMS. (y)

CCCXXXVII. GENTIAN. (z)

CCCXXXVIII. GILDING. Gilding is the art of applying exceedingly thin layers of gold upon the ſurfaces of certain ſubſtances, to give them the external appearance of gold.

The luſtre and beauty of gold have occaſioned ſeveral inquiries and diſcoveries concerning the different methods of applying it to different ſubſtances. Hence the art of gilding is very extenſive, and contains many particular operations, and various management.

A color of gold is given by painting and by varniſhes, without employing gold; but this is a falſe kind of gilding. Thus a very fine golden color is given to braſs, and to ſilver, by applying upon theſe metals a gold-colored varniſh, which being tranſparent, ſhews all the brilliancy of the metals beneath. Many ornaments of braſs are varniſhed in this manner, which is called *gold lacquering*, to diſtinguiſh them from thoſe which are really gilt. Silver-leaves thus varniſhed are put upon leather, which is then called gilt leather. (a)

(x) GELATINOUS *and* GELLY. *See* JELLY.

(y) GEMS are certain ſtones conſiſting of the *ſiliceous*, or what is improperly called *vitrifiable* earth, much valued for their luſtre, tranſparency, color, hardneſs, weight, and rarity. Theſe are, diamonds, rubies, ſaphirs, topazes, emeralds, chryſolites, amethyſts, garnets, hyacinths or jacinths, berylls or aqua marinas. The order in which they are enumerated ſhows their relative degrees of hardneſs. See *each of theſe articles*, DIAMONDS, RUBIES, &c.

(z) GENTIAN. From ſixteen drams of the root of gentian Neuman obtained ſix drams and a half of reſinous extract by means of ſpirit of wine, which contained all the bitterneſs of the gentian; and from the ſame quantity he obtained nine drams of gummy extract, which was conſiderably bitter, but leſs ſo than the ſpirituous extract.

(a) The baſis of theſe lacquers is a ſolution of the reſinous ſubſtance, called ſeed-lac, in ſpirit of wine. The ſpirit of wine muſt be very much dephlegmated, and for this purpoſe authors direct dry pot-aſh to be thrown into it, which attracts the water, and with it forms a liquid diſtinct from the ſpirit; which being collected at the bottom of the veſſel, may be ſeparated by decanting the ſpirit. By this method the ſpirit is much dephlegmated; but, at the ſame time, it diſſolves a part of the alkaline ſalt, by which it acquires color, and alſo communicates a property to the lacquer of imbibing moiſture from air. Theſe inconveniencies are prevented by adding to the ſpirit of wine thus dephlegmated ſome calcined alum, the acid of which unites with the alkaline ſalt remaining in the ſpirit, and forms with it a vitriolated tartar; which not being ſoluble in ſpirit of wine, falls to the bottom, together with the earth of the decompoſed alum, and the ſuperfluous alum, if more be added than is neceſſary. To a pint of the ſpirit thus

Amongſt the falſe gildings may alſo be reckoned thoſe which are made with thin leaves of copper or braſs, called *Dutch leaf*. In this manner are made all the kinds of what is called gilt paper.

In the true gilding, gold is applied to the ſurface of bodies. The gold intended for this purpoſe ought in general to be beat into thin leaves, or otherwiſe divided into very fine parts.

As metals cannot adhere well merely by contact to any but to other metallic ſubſtances, when gold is to be applied to the ſurface of ſome unmetallic body, that ſurface muſt be previouſly covered with ſome gluey and tenacious ſubſtance, by which the gold ſhall be made to adhere. Theſe ſubſtances are in general called *ſizes*. Some of theſe are made of vegetable and animal glues, and others of oily, gluey, and drying matters. Upon them the leaves of gold are applied; and when the whole is dry, the work is to be finiſhed and poliſhed. Wood chiefly is gilt in this manner; but it muſt be previouſly covered with ten or twelve layers of chalk, mixed with glue diſſolved in water. That forms a body or coat, which hurts the ſculpture and mouldings upon the wood; but is neceſſary for furniſhing the gold with a ſofter ſupport; otherwiſe, if the gold was applied to the wood without the interpoſition of this ſize, it would be apt to be torn and rubbed off, when burniſhed, that is, poliſhed with a hard inſtrument, called a *dog's tooth*, to give it luſtre. (*b*)

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dephlegmated, about 3 ounces of powdered ſhell lac are to be added; and in a day or two, by help of moderate heat, the ſpirit will have acquired a reddiſh color. It ought then to be poured off, ſtrained, and cleared by ſettling: then as much gamboge and arnotto are to be added as are ſufficient to give it the color required, which muſt be diſcovered by frequently trying the mixture upon ſilver leaf. Theſe two ſubſtances are readily ſoluble in the above deſcribed tincture of lac. For the greater conveniency of mixing them in any proportion, the beſt method is to diſſolve them ſeparately in two quantities of the tincture of lac; and thus the color of the lacquer may be adjuſted by mixing together the ſolution of gamboge, which is yellow, with that of annotto, which is reddiſh-yellow. Generally two parts of the ſolution of gamboge are added to one part of the ſolution of annotto. Saffron, dragon's blood, turmeric, and other red and yellow coloring materials, are ſometimes uſed for the ſame purpoſes, but are not preferable to the two above-mentioned. The varniſh is then to be laid, with a bruſh, upon the leaves of ſilver or of tin, previouſly fixed upon the piece of work by the intervention of ſome ſize; and when the varniſh is dry, other layers are to be ſpread till it be ſufficiently thick. A varniſh containing leſs of the coloring materials than the above is applied upon works of braſs to heighten the color, and preſerve it from tarniſhing.

(*b*) When wood, paper, and ſuch ſubſtances are to be gilded, they muſt be previouſly covered with ſome glutinous ſubſtance, upon which, when almoſt dry, gold leaf is to be applied, and preſſed down with a little cotton, or hare's foot. When the matter is dry, the gold is to be burniſhed. When the work is required to be capable of reſiſting rain or moiſture, it ought to be previouſly covered with a compoſition of drying oil and yellow ochre ground together; otherwiſe a water-ſize may be uſed, which is prepared by boiling cuttings of parchment or white leather in water, and by mixing with this ſome chalk or whiting; ſeveral layers of this ſize muſt be laid upon the wood, and over theſe a layer of the ſame ſize mixed with yellow ochre. Laſtly, another mixture, called *gold ſize*, is to be applied above theſe; upon which the gold leaves are to be fixed. This gold ſize, the uſe of which is to make the gold leaf capable of being burniſhed, is compoſed of tobacco-pipe clay, ground with ſome ruddle or black lead, and tempered with a little tallow or oil of olives. The edges of glaſſes may be gilt by applying, firſt, a

The method of applying gold upon metals is entirely different. The ſurface of the metal to be gilt is firſt to be cleaned; and then leaves are to be applied to it, which, by means of rubbing with a poliſhed blood-ſtone and a certain degree of heat, are made to adhere perfectly well. (*c*)

Gold is applied to metals in ſeveral other manners. One of theſe is by previouſly forming the gold into a paſte or amalgam with mercury. *See* AMALGAM.

With this amalgam the ſurface of the metal to be gilded is to be covered; then a ſufficient heat is to be applied to evaporate the mercury; and the gold is laſtly to be burniſhed with a blood-ſtone. (*d*)

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a very thin coat of varniſh, upon which the gold leaf is to be fixed; and when the varniſh is hardened, may be burniſhed. This varniſh is prepared by boiling powdered amber with linſeed oil in a braſs veſſel to which a valve is fitted, and by diluting the above ſolution with four or five times its quantity of oil of turpentine; and that it may dry ſooner, it may be ground with ſome white lead.

(*c*) In this manner ſilver leaf is fixed and burniſhed upon braſs in the making of what is called *French plate*, and ſometimes alſo gold leaf is burniſhed upon copper and upon iron.

(*d*) This method of gilding by amalgamation is chiefly uſed for gilding copper, or an allay of copper, with a ſmall portion of zinc, which more readily receives the amalgam, and is alſo preferable for its color, which more reſembles that of gold than the color of copper. Of the method of preparing the amalgam of gold, *ſee the word* AMALGAM. The proportion of mercury to gold is generally as ſix or eight to one. When the metal to be gilt is wrought or chaſed, it ought to be previouſly covered with quickſilver, before the amalgam is applied, that this may be eaſier ſpread: but when the ſurface of the metal is plain, the amalgam may be applied directly to it. The quickſilver or amalgam is made to adhere to the metal by means of a little aqua-fortis, which is rubbed on the metallic ſurface at the ſame time, by which this ſurface is cleanſed from any ruſt or tarniſh which might prevent the union or adheſion of the metals. The uſe of the nitrous acid in this operation is not confined merely to cleanſe the ſurface of the metal to be gilt from any ruſt or tarniſh it may have acquired; but it alſo greatly facilitates the application of the amalgam to the ſurface of that metal, in the following manner: It firſt diſſolves part of the mercury of the amalgam; and when this ſolution is applied to the copper, this latter metal having a ſtronger diſpoſition to unite with the nitrous acid than the mercury has, precipitates the mercury upon its ſurface, in the ſame manner as a poliſhed piece of iron precipitates upon its ſurface copper, from a ſolution of blue vitriol. When the metal to be gilt is thus covered over with a thin coat of mercury, it readily receives the amalgam. In this ſolution and precipitation of mercury, the principal uſe of the nitrous acid in the proceſs of gilding appears to me to conſiſt. The amalgam being equally ſpread over the ſurface of the metal to be gilt, by means of a bruſh; the mercury is then to be evaporated by a heat juſt ſufficient for that purpoſe; for if it be too great, part of the gold may alſo be expelled, and part of it will run together, and leave ſome of the ſurface of the metal bare: while the mercury is evaporating, the piece is to be, from time to time, taken from the fire, that it may be examined, that the amalgam may be ſpread more equally by means of a bruſh, that any defective parts of it may be again covered, and that the heat may not be ſuddenly applied to it: when the mercury is evaporated, which is known by the ſurface being entirely become of a dull yellow color, the metal muſt then undergo other operations by which the fine golden color is given to it. Firſt, the gilded piece of metal is rubbed with a ſcratch-bruſh, (which is a bruſh compoſed of braſs wire) till its ſurface is made ſmooth; then it is covered over with a compoſition called *gilding wax*, and is again expoſed to the fire till the wax be burnt off. This wax is compoſed of bees-wax mixed with ſome of the following

Finally, ſome metals, particularly ſilver, may be gilt in the following manner:

Let gold be diſſolved in aqua regia. In this ſolution pieces of linen are to be dipt, and burnt to black aſhes. Theſe aſhes being rubbed on the ſurface of the ſilver by means of a wet linen rag, apply the particles of gold which they contain, and which by this method adhere very well. The remaining part of the aſhes is to be waſhed off; and the ſurface of the ſilver, which in this ſtate

ing ſubſtances; red ochre, verdegriſe, copper-ſcales, alum, vitriols, borax. By this operation the color of the gilding is heightened; but muſt be further improved by another operation. This conſiſts in covering over the gilt ſurface with a ſaline compound; in expoſing it thus covered to heat till the ſaline matters acquire a certain color and appearance, known to artiſts; and laſtly, in ſuddenly quenching it when thus brought to its proper degree of heat, in urine, water, or other liquid. Different artiſts uſe different receipts for the preparation of the ſaline compound; but all, or moſt of theſe receipts contain nitre, ſal ammoniac, or common ſalt, alum, or ſome vitriolic ſalt; to which they add verdegriſe, borax, or other matters; all which muſt be powdered and mixed, or boiled, with urine. Some artiſts think that they give an additional luſtre to their gilt work, by dipping it after it has undergone the foregoing operations in a liquor prepared by boiling ſome yellow material, as ſulphur, orpiment, or turmeric, in water or in urine, together with tartar, common ſalt, and other ſaline ſubſtances. Theſe operations cannot be well explained, unleſs experiments were made to diſcover by what of the numerous ſubſtances uſed at the ſame time, the effects are produced. In the mean time, I will hazard ſome conjectures concerning this ſubject. The effect produced by flaming off the gilding wax is the heightening of its color; and ſeems to me to be cauſed by a more thorough diſſipation of ſome mercury remaining after the firſt evaporation of it, which is well effected by this equable application of heat. The effect produced by the ſaline compound is that of giving the genuine color of gold, entirely ſimilar to that of a piece of gold dipped in aqua regia, by which any tarniſh upon its ſurface is diſſolved, and its true color is made to appear. Accordingly, in all the receipts which I have ſeen for the preparation of this ſaline compound, I have always found one ingredient to be nitre, another to be common ſalt or ſal ammoniac, and a third to be alum or ſome vitriol. Now, by expoſing theſe to the fire, an aqua regia is actually produced, the vitriolic acid of the alum or of the vitriolic ſalt decompoſing the other two ſalts containing the marine and nitrous acids; by which means theſe acids are ſo diſengaged that they can, thus formed into an aqua regia diſſolve ſome of the ſurface of the gold, and thus give it its genuine color. This action of the marine and nitrous acids upon the gold muſt evidently be continued but an exceeding ſhort time; the artiſt therefore watches the appearance of the ſaline compound, which, from the urine or other ſubſtance containing ſome inflammable matter, becomes black, upon the application of a certain degree of heat; and then he quickly plunges it in water. Laſtly, the only advantage from the laſt operation is, that a part of the yellow matter, as the ſulphur, or turmeric, remains in ſome of the hollows of the carved work, in which the gilding is apt to be more imperfect, and to which it gives a rich and ſolid appearance.

Iron cannot be gilt by amalgamation, unleſs, as it is ſaid, it be previouſly coated with copper by dipping in a ſolution of blue vitriol. Iron may alſo receive a golden coat from a ſaturated ſolution of gold in aqua regia, mixed with ſpirit of wine, the iron having a greater affinity with the acid, from which it therefore precipitates the gold. Whether any of theſe two methods be applicable to uſe, I do not know; but the method commonly employed of fixing gold upon iron is that above-mentioned, of burniſhing gold-leaf upon this metal when heated ſo as to become blue; and the operation will be more perfect if the ſurface has been previouſly ſcratched or graved.

does not ſeem to be gilt, is to be burniſhed with a blood-ſtone, till it acquire a fine color of gold. This method of gilding is very eaſy, and conſumes a very ſmall quantity of gold. Moſt gilt ornaments upon fans, ſnuff-boxes, and other toys of much ſhow and little value, are nothing but ſilver gilt in this manner.

Gold may alſo be applied to glaſs, porcelain, and other vitrified matters. As the ſurface of theſe matters is very ſmooth, and conſequently is capable of a very perfect contact with gold leaves, theſe leaves adhere to them with ſome force, although they are not of metallic nature. This gilding is ſo much more perfect, as the gold is more exactly applied to the ſurface of the glaſs. The pieces are then to be expoſed to a certain degree of heat, and burniſhed ſlightly to give them luſtre. (e)

Theſe are the principal methods of gilding. *Silvering* is performed by proceſſes very ſimilar to theſe, and founded on the ſame principles. (f)

CCCXXXIX. GILLA VITRIOLI. This name is given to white vitriol purified by cryſtallization, which was formerly given as an emetic, from half a ſcruple to a dram. *See* Vitriol.

CCCXL GINGER. (g)

Another method is mentioned by authors of gilding upon metals, and alſo upon earthen ware, and upon glaſs; which is, to fuſe gold with regulus of antimony, to pulverize the maſs which is ſufficiently brittle to admit that operation, to ſpread this powder upon the piece to be gilt, and expoſe it to ſuch a fire that the regulus may be evaporated, while the gold remains fixed. The inconveniencies of this method, according to Dr. Lewis, are, that the powder does not adhere to the piece, and cannot be equably ſpread; that part of the gold is diſſipated along with the regulus; that glaſs is fuſible with the heat neceſſary for the evaporation of regulus of antimony; and that copper is liable to be corroded by the regulus, and to have its ſurface rendered uneven.

(e) A more ſubſtantial gilding is fixed upon glaſs, enamel, and porcelain, by applying to theſe ſubſtances powder of gold mixed with a ſolution of gum arabic, or with ſome eſſential oil, and a ſmall quantity of borax; after which a ſufficient heat is to be applied to ſoften the glaſs and the gold, which is then to be burniſhed. With this mixture any figures may be drawn. The powders for this purpoſe may be made, 1. By grinding gold leaf with honey, which is afterwards to be waſhed away with water; 2. By diſtilling to dryneſs a ſolution of gold in aqua regia; 3. By evaporating the mercury from an amalgam of gold, taking care to ſtir well the maſs near the end of the proceſs; 4. By precipitating gold from its ſolution in aqua regia by applying to it a ſolution of green vitriol in water, or ſome copper, and perhaps ſome other metallic ſubſtances.

(f) *Silvering* by amalgamation is ſeldom practiſed, as it does not ſucceed nearly ſo well as the gilding by amalgamation. The common method of ſilvering metals, as braſs, or of making French plate, is that mentioned above of burniſhing ſilver leaves, from twenty to ſixty, upon the piece of metal previouſly heated.

(g) Ginger. From ſixteen ounces of the *root* of common ginger, about a dram of oil poſſeſſing the ſmell and flavor, but not the pungency of the ginger, may be obtained by diſtillation. The ſame quantity of root yielded with rectified ſpirit an ounce and two ſcruples of reſinous extract, containing all the pungent matter of the root. Water alſo extracted four ounces from ſixteen ounces of the root. The watery extract was conſiderably pungent, but it ſeems to receive its pungency from ſome part of the reſin which is mixed with it; for the reſin remaining in the root after the extraction by water, contains greateſt part of the pungent matter. *Neuman.*

CCCXLI. GLACIES MARIÆ. (b)

CCCXLII. GLASS Glaſs is a hard, ſolid, brittle, tranſparent ſubſtance. It reſiſts, when it is of a good quality, the action of air, water, acids, and all other menſtruums. Laſtly, it is not fuſible without a very ſtrong heat.

The large quantity of vitrifiable earth which enters into the compoſition of glaſs, gives it all theſe qualities. But as this earth is ſo difficultly fuſible, when it is pure, that it cannot be fuſed and vitrified by the greateſt fires of our furnaces, other matters, and particularly ſalts, muſt be mixed with it, by which its fuſion is facilitated, and ſo intimate an union is formed, that it makes with them but one body. Theſe fluxes therefore enter into the compoſition of glaſs. We only give here the definition of glaſs, and refer to the article VITRIFICATION for what we have to ſay on this important ſubject.

CCCXLIII. GLASS *of* ANTIMONY. The method of preparing glaſs of antimony, is by calcining crude antimony with a moderate heat till no more vapors of ſulphur riſe, and till it be reduced to a grey aſh-colored earth or calx. This calx is then to be put into a crucible, placed in a good melting furnace; and a ſufficiently ſtrong heat is to be applied during an hour, or an hour and an half, or rather till it be converted into a tranſparent glaſs. The operation may be known to have been well made, by dipping an iron rod into the crucible. In that caſe, ſome vitrified matter will adhere to the end of the iron rod, and will be capable of being drawn out into fine wire, like ordinary glaſs. The crucible is then to be taken from the furnace, and the glaſs is to be caſt upon a ſmooth plate of copper, which ought to have been previouſly heated to dry it perfectly. This glaſs, when cold, is of a tranſparent hyacinthine color, more or leſs yellow or reddiſh.

The earths of all metallic matters are diſpoſed to fuſion and vitrification, when they ſtill retain a portion of their inflammable principle. If this portion be too large, they may be melted more eaſily, but the maſs will be opake, and more or leſs approaching the metallic ſtate. If, on the contrary, theſe earths are too much dephlogiſticated, they are ſo much more refractory, as they have loſt more of their phlogiſton, and at laſt become entirely unfuſible, at leaſt in the fires of our furnaces, when ſo much dephlogiſticated as to poſſeſs only the properties of pure earths. Therefore metallic glaſs ought to be conſidered as in a ſtate intermediate betwixt that of metals and of earths. Accordingly the glaſs of antimony, like all the others, is ſo much more colored, fuſible, heavy, and leſs tranſparent, as the antimony employed has been leſs calcined.

As glaſs of antimony is chiefly prepared for the purpoſes of medicine; and as its emetic quality, which is its chief virtue, depends on the quantity of inflammable principle which it retains; this glaſs, to be well conditioned, ought to be moderately fuſible and tranſparent, of a hyacinthine color, not too clear, nor too deep; laſtly, it ought to ſmoke, while it remains fuſed.

(b) GLACIES MARIÆ, or *lapis ſpecularis*, is a tranſparent, laminated, ſelenitic or gypſeous ſtone. For its properties *ſee* GYPSUM. Its appearance is very ſimilar to that of talk, but differs from it in this circumſtance, that the plates of which talk conſiſts are flexible, while thoſe of glacies mariæ are inflexible. Some of theſe laminated gypſums have a rhomboidal form, and are then called *ſelenites*, or *gypſeous ſpat*: others have no determinate form.

When the glaſs is poured out, this ſmoke condenſes partly in white flowers, which fix upon the ſurface of the glaſs and upon the plate of copper.

Hence the eſſential point for making beautiful and good glaſs of antimony is, to give the antimony the preciſe degree of calcination which is neceſſary; which is not very eaſy. Accordingly the operation ſometimes fails; but the exceſs or defect of the calcination may be remedied. If the calx be too fuſible, and if it flow into a fluid matter which is not tranſparent, nor is capable of being drawn out into wire, as glaſs is, we may conclude that the calx has not been ſufficiently calcined. In this ſtate, the fire ought to be diminiſhed, the crucible uncovered, and, after the matter has been allowed to ſmoke during a certain time, the fire may be encreaſed, and a tranſparent glaſs will be obtained. But if, on the contrary, the calx cannot be made to flow or vitrify well, this ſhows that the calx has been too much calcined. This fault may be remedied by throwing into the crucible about a ſixteenth part of the weight of the calx, of crude antimony, and then fuſing the whole. This ſmall quantity of crude antimony not only gives phlogiſton to the calx, which thereby becomes more fuſible, but alſo ſome mineral ſulphur, which produces the ſame effect; for glaſs of antimony ſeems always to retain a certain quantity of ſulphur.

When the calx of antimony employed for the preparation of this glaſs is evidently of difficult fuſion, a very ſtrong heat ought to be applied quickly; for by being kept long moderately hot in the crucible before it is fuſed, it is more and more calcined, and at laſt rendered unfuſible. Some calxes are ſuppoſed to have been too much calcined for this operation, becauſe they were not expoſed to ſtrong fire ſufficiently quickly.

Glaſs of antimony is more eaſily and perfectly ſoluble in acids, and particularly in oily acids, than the regulus; wherefore, when taken internally, it produces more conſiderable effects as an emetic. For this reaſon alſo, it is combined with cream of tartar for the preparation of *ſtibiated* or *emetic tartar*.

Formerly it was given medicinally without other preparation than levigation. But its uſe has been relinquiſhed by prudent phyſicians from the violence and uncertainty of its effects, which are produced by the ſame cauſes as thoſe explained under the article TARTAR (EMETIC). Nevertheleſs it is given ſucceſsfully by very able phyſicians in ſome diſeaſes, as in the colic of miners. But notwithſtanding the experience which has eſtabliſhed the uſe of it in theſe caſes, probably emetic tartar might be adminiſtered with equal ſucceſs and greater certainty; and, if neceſſary, in more frequent and larger doſes than in ordinary caſes. *See* TARTAR (EMETIC).

CCCXLIV. GLASS *of* ANTIMONY CORRECTED *by* WAX. A method has lately been practiſed in England to render the glaſs of antimony milder; and this preparation has been commended as an excellent remedy in dyſenteries, and lochial hemorrhages. It is made by melting a dram of yellow wax in an iron ladle, and by adding to this an ounce of levigated glaſs of antimony, in a fire continued during half an hour, and juſt ſtrong enough to diſſipate almoſt entirely the wax without inflaming it. When the matter is cooled, it appears of a brown color. It is again to be levigated, and is called the glaſs of antimony corrected by wax, or *vitrum ceratum antimomii.* The doſe of it is from ſix grains to ten or twelve.

The emetic quality of glaſs of antimony is indeed diminiſhed by this preparation, becauſe the wax evidently furniſhes a certain quantity of phlogiſton, and approximates it more to the ſtate of the regulus, or rather of the liver of antimony, both which are leſs emetic than the glaſs. But this waxed glaſs muſt evidently be ſubject to the inconveniencies of theſe other preparations of antimony, particularly to the inequality of their effects, and for the ſame reaſon. By introducing this new remedy, therefore, a kind of preparations eſſentially faulty, and relinquiſhed for good reaſons, has again been brought into uſe, without conſidering, that the diſeaſes, for which it is recommended, proceed from different cauſes, and ought not to be treated with the ſame remedies; as Mr. Baron has judiciouſly remarked in his edition of Lemery's Chemiſtry.

CCCXLV. GLASS *of* BORAX. Borax is, as we have ſaid under that article, a neutral ſalt, which when expoſed to fire, loſes the water of its cryſtallization; and by a ſtronger heat is further fuſible into a matter which may be drawn out, while hot, into wire, like ordinary glaſs; and which when cold, has the appearance of a very white, tranſparent glaſs. Borax thus perfectly fuſed has been called a glaſs, from its reſemblance to vitrified matters. This glaſs of borax differs nevertheleſs from true glaſs by the ſaline properties which it retains; it being entirely ſoluble in water, and again cryſtallizable into its original form of borax. It is ſuſceptible of the ſame decompoſitions as borax; in a word, it does not differ eſſentially from borax, but only in being more dry, or deprived of water.

To obtain very beautiful glaſs of borax, it ought to be guarded againſt aſhes and coals, which is conveniently done by melting it in a muffle. As this matter is very fuſible, and at the ſame time capable of facilitating much the fuſion and vitrification of ſand, and other earthy matters, it is advantageouſly uſed in the eſſays of ores, and as an ingredient in compoſitions for glaſſes and artificial cryſtals. But for this latter purpoſe a very ſmall proportion only ought to be uſed, as it imparts to glaſs the ſame property it has itſelf, of loſing its luſtre by expoſure to air. Glaſs of borax is preferred to borax for theſe purpoſes; becauſe it is deprived of all ſuperfluous moiſture, and is not ſubject to ſwell, as the borax is. *See* BORAX.

CCCXLVI. GLASS *of* LEAD. Lead is a metal eaſily calcinable; but it has a ſingular property, that when it has loſt ſo much of its phlogiſton that it cannot be reduced into metal without addition, it then retains the remaining part of its phlogiſton more ſtrongly than any other metallic matter. Hence ceruſs or white lead, minium, litharge, and all the other preparations and calxes of lead, retain always great fuſibility, and are much diſpoſed to vitrification. All theſe matters, by a moderate fire only, are eaſily fuſed, and formed into a tranſparent glaſs of a deep yellow color. But this glaſs is ſo penetrating and ſo powerful a flux, that it paſſes through crucibles as ſoon as it melts; and when it has been kept long enough in the fire to be perfectly fuſed and vitrified, none of it is to be found in the crucible, which is then glazed over internally and externally.

This property of glaſs of lead proceeds from its powerful action upon all earthy matters, by which it diſpoſes them to vitrify. Hence the difficulty of obtaining a pure glaſs of lead. A greater conſiſtence muſt be given to it, and its activity muſt be repreſſed, by uniting it with ſand, in the following manner, to render it fit for uſe.

Take two parts of a calx of lead, minium for inſtance, and one part of ſand or powdered flints. Put this mixture into a good crucible made of refractory clay, baked into a very compact body. Place this crucible in a melting furnace, after having cloſed it well with a luted lid. This crucible is to be heated by degrees, and very ſlowly; not only to prevent the breaking of the crucible, to which this kind of crucible is very ſubject, when heated too quickly, but to hinder the matter from ſwelling too much, and flowing over the crucible in the beginning of the fuſion. During an hour or an hour and a half, the fire muſt be thus managed in the beginning of the operation, and afterwards it may be encreaſed, to obtain a compleat fuſion, and continued in that ſtate during an hour or an hour and a half; after which the crucible is left to cool in the furnace; and when it is broken, a very tranſparent yellow colored glaſs is found in it. Some chemiſts direct the addition of ſome nitre and common ſalt to the above mixture, as theſe ſalts promote the fuſion, and the more equal diſtribution of the ſand.

This glaſs, which, as we have ſeen, is not a pure glaſs of lead, but in which the lead is the prevailing ingredient, has a conſiderable ſpecific gravity, and its lower part is always the heavieſt. As it is very fuſible, and eaſily re-melted with a moderate fire, and as it is beſides a very powerful flux, it is advantageouſly employed in eſſays of ores to facilitate their ſcorification. *See* LEAD *and* VITRIFICATION.

CCCXLVII. GLASS-GALL. This is a ſaline matter which riſes as a ſcum in the pots or crucibles in which glaſs is made.

This matter is chiefly compoſed of Glauber's ſalt, common ſalt, vitriolated tartar, or other neutral ſalts which cannot enter into vitrification, and which were originally contained in the aſhes or alkalis employed in the compoſition for glaſs. Glaſs-gall is uſed to facilitate the fuſion of certain ores, and in eſſays; but this matter muſt vary much, according to the kinds of alkalis or aſhes from which it is produced. (*i*)

(*i*) *Glaſs-gall.* called alſo *Sandiver*, is ſaid to contain the vitriolic acid, although no vitriolic ſalt was employed in the compoſition for the glaſs. The vitriolated tartar which is in all pot-aſh and wood-aſhes employed in the manufacture of glaſs, might account for the exiſtence of vitriolic acid in common glaſs-gall; but Pott affirms, that by melting together fixed alkali, flints, and common ſalt, a ſalt of Glauber may be produced, which he thinks very ſimilar to glaſs-gall in many of its properties; but from which, however, it differs in this, that it deliquiates by expoſure to air, whereas the ſalt of Glauber falls into a dry powder. Tachenius ſuppoſes that the vitriolic acid of glaſs-gall proceeds from the flints. Its cryſtals reſemble, as Mr. Pott ſays, partly vitriolated tartar, and partly the ſalts of mineral water. It differs from vitriolated tartar in being more fuſible, more ſoluble in water, and in being even deliqueſcent. It is uſed as a flux in eſſays of ores, and in the fuſion of filings of gold or ſilver, in the ſame manner as borax is. It is even ſaid to increaſe the malleability of metals. *See Pott's Diſſertation on Glaſs-gall.*

CCCXLVIII. GOLD. Gold, called alſo by chemiſts the *Sun*, *Sol*, and the *king of metals*, is a perfect metal, of a yellow ſplendid color, and unalterable by all the operations of art. This is the moſt perfect of all metals; its principles are the beſt combined, and it poſſeſſes moſt eminently the metallic characteriſtics.

When gold is very pure, it has no taſte nor ſmell, even when heated and rubbed. It loſes in water betwixt $\frac{1}{19}$ and $\frac{1}{20}$ part of its weight. A cubic foot of gold weighs 1326 pounds. It is the heavieſt of all metals, and conſequently of all known bodies.

The hardneſs of gold is intermediate betwixt that of the hard and of the ſoft metals. Its ductility is ſurprizingly great, and exceeds that of all metals. From calculations made by experimental philoſophers concerning the extenſion of gold upon ſilver, a ſingle ounce of gold, the bulk of which is very ſmall on account of its great weight, is found to be capable of covering and gilding perfectly a ſilver wire 444 leagues in length.

The gold-beater's art, by which gold is formed into ſuch thin leaves that they are made to float in the air by a light breath, is a further proof of its great ductility, and is alſo a proof of its extreme opacity: for theſe gold leaves are ſtill perfectly opake. Light may indeed be perceived through them; but this is owing to cracks, which may be eaſily perceived upon examining the leaves, and which are occaſioned by the repeated ſtrokes of the hammer.

When gold is ſtruck during a certain time by a hammer, or when violently compreſſed, as it is by gold-wire-drawers, it becomes more hard, elaſtic, and ſtiff, and leſs ductile, ſo that it is apt to be crackt and torn. The ſame thing alſo happens to the other metals by percuſſion and compreſſion. Ductility and tractability may be reſtored to metals in that ſtate, by making them red-hot, which is called *annealing* them. Gold ſeems to be more affected by percuſſion and by annealing than other metals.

The tenacity of the parts of gold is alſo much greater than of any other metal. For 500 pounds can be ſupported by a wire of $\frac{1}{10}$ of an inch in diameter made of gold, but not of any other metal.

Gold is unalterable by air and by water. It never contracts any ruſt; and when its ſurface loſes its luſtre, this is occaſioned by the adheſion of extraneous matters, and not by any deſtruction of the metal. The action of fire does not occaſion any alteration upon gold. When expoſed to fire it ſoon becomes red, and when it has acquired a vivid redneſs, like that of a burning coal, it ſoon melts. Its ſurface has then a light green color, like that of a beryl. No vapor or ſmoke riſes from gold during its fuſion; and it ſuffers no loſs of weight by that operation, however long continued, or with the moſt violent fire. Kunckel kept gold in a glaſs-houſe furnace during a month and Boyle kept ſome ſtill longer expoſed to great heat, without the loſs of a ſingle grain or any alteration.

Gold reſiſts alſo, while its aggregation is entire, the action of the ſtrongeſt ſimple chemical menſtruums, either in the dry or in the humid way. It is not ſoluble either by the ſtrongeſt mineral acids when they are pure, nor by ſulphur, nor by alkalis. Two compound bodies, nevertheleſs, are powerful ſolvents of gold. The firſt is a mixture of the nitrous and marine acids, called by chemiſts *aqua regia*, becauſe it diſſolves gold, the king of metals; and the ſecond ſolvent of gold is a combination of ſulphur with fixed alkali, called *liver of ſulphur*.

The ſolution of gold in aqua regia is very eaſy. A very ſmall quantity of nitrous acid, or even of inflammable matter, mixed with marine acid, gives this latter acid the property of attacking gold. Alſo a very ſmall quantity of marine acid, or of any of the ſalts containing it, mixed with nitrous acid, renders this nitrous acid capable of diſſolving a certain quantity of gold. But experience has ſhown, that an aqua regia compoſed of four parts of nitrous acid, and one of ſal ammoniac, diſſolves perfectly well a fourth or a third part of its weight of gold, according to the ſtrength of the acid. *See* AQUA REGIA.

To make this ſolution, the gold is to be reduced into filings or thin plates, and put into a ſmall matraſs. Upon this gold the aqua regia is to be poured, and the matraſs is to be placed in a ſand-bath moderately heated. As ſoon as the aqua regia is ſufficiently heated, it attacks the gold with all the uſual phenomena which accompany ſolutions of metals in acids. But in this ſolution the efferveſcence is only moderate. While the aqua regia diſſolves the gold, it acquires a beautiful yellow color, which becomes more and more intenſe, till it has a golden, or even an orange color. When the menſtruum is entirely ſaturated with gold, the ſolution is very clear and tranſparent.

The power which the nitrous and marine acids acquire by their union, of diſſolving gold, which neither of them have ſeparately, is one of the moſt remarkable facts in chemiſtry, and favours much the opinion which admits the three earths or principles of Becker as the conſtituent parts of metals, becauſe that fact is well explained by this doctrine. If marine acid contains the mercurial principle, as nitrous acid contains the inflammable principle; and if, on the other ſide, both theſe principles conſtitute metals, by their union with the earthy principle; we may eaſily conceive that all thoſe metallic matters, in which the union of theſe principles is weak and imperfect, may be attacked indiſcriminately by the nitrous and marine acids ſeparately: becauſe when any of theſe acids finds in the metallic matter the principle which is analogous to it, weakly combined, it may be capable of attacking that metallic matter, by means of this analogous principle. But if theſe principles be ſtrongly united together, as many reaſons concur to prove they are in gold, ſince it is the moſt perfect and indeſtructible of metals; then we may eaſily conceive that while theſe acids act on the gold ſeparately, the mercurial principle may be defended from the action of the marine acid by the inflammable principle, and reciprocally the inflammable principle may be defended from the action of the nitrous acid by the mercurial principle; and that thus gold cannot be diſſolved by either of theſe two acids ſeparately.

But we may at the ſame time eaſily perceive, that if two acids united make a combined attack upon gold, that is, if the marine acid attacks the mercurial principle of the metal, while the nitrous acid attacks the inflammable principle, the action of this compound menſtruum will be twice as ſtrong as that of any of the two acids ſeparately, and they may therefore perform the ſolution conjointly, which neither of them could do ſingly.

Gold receives no alteration in its compoſition from the acids of aqua regia. This ſolution is corroſive, as alſo all other metallic ſolutions are. It gives a violet color to the fingers, or to any animal matters, for the ſame reaſon that ſolutions of ſilver and mercury in nitrous acid tinge theſe matters black. If the ſolution be evaporated and cooled, yellow tranſparent cryſtals like ſmall topazes will be formed. But if the evaporation be carried too far, the acids with which the gold is united may be driven from it by heat alone, and the gold will be left in the ſtate of a yellow powder, called *calx of gold.*

Gold may be precipitated from its ſolution by thoſe intermediate ſubſtances which generally precipitate metals from acids; that is, by alkalis fixed and volatile, by calcareous earths, and by ſome other metals. But volatile alkali ſeems to precipitate gold more eaſily than fixed alkalis; at leaſt gold is very ſlowly precipitated from an aqua regia made without ſal ammoniac by fixed alkali, but is copiouſly and inſtantly precipitated by volatile alkali. Fixed alkali alſo precipitates it copiouſly and ſpeedily from aqua regia made with ſal ammoniac; but in this caſe the volatile alkali in the nitrous ammoniacal ſalt, contained in this aqua regia, is evidently diſengaged by the fixed alkali, and contributes to the precipitation.

All theſe precipitates of gold, although yellow, have not a metallic brilliancy, becauſe they retain part of the diſſolving and precipitating ſalts. In other reſpects, they, and alſo the calx of gold above-mentioned, are nothing but gold unaltered; and when melted without addition, become entirely like the metal before it was diſſolved.

Gold precipitated by a volatile alkali from its ſolution in aqua regia has an aſtoniſhing property, namely, its power of exploding with violence and terrible noiſe, when heated to a certain degree. It is accordingly called *fulminating gold. See* GOLD (FULMINATING). This property has not been obſerved in any other metal.

Although a maſs of gold, that is, gold, the aggregation of which is entire, reſiſts the action of ſimple ſolvents, as we have ſeen, we muſt not conclude that it is abſolutely incapable of ſolution by any of theſe ſimple ſolvents. On the contrary, Mr. Margraaff has diſcovered, that this metal, precipitated by an alkali from its ſolution in aqua regia, is then rendered ſoluble by any, even the vegetable, acids. Beſides, gold diſſolved in aqua regia is not precipitated, when the proportions of the two acids of this compound menſtruum are changed, by adding to this ſolution any quantity of nitrous or of marine acids. Laſtly, gold may be diſſolved in alkalis by the proceſs of the martial alkaline tincture of Stahl; that is, by pouring into a concentrated ſolution of fixed alkali in water, a ſmall quantity of ſolution of gold in aqua regia in which the acids are not too much ſaturated, the gold will be quickly ſeized and diſſolved by the alkali.

All theſe experiments prove, that the juſt proportion and intimate connection of the principles of the gold are not the only cauſes which render it inſoluble, or difficultly ſoluble by menſtrua which eaſily attack the other metals, but that its great denſity and ſtrength of its aggregation contribute alſo much to this effect; ſince, when this aggregation is broken by a previous ſolution in aqua regia, it eaſily yields to the action of other ſolvents.

Moſt metals are capable of ſeparating gold from aqua regia by precipitation. The precipitate occaſioned by adding tin is the moſt remarkable of theſe. It has not the metallic ſplendor, as metals precipitated by other metals generally have; but it is of a beautiful purple color, when well made. This precipitate, called *Caſſius's precipitate of gold*, is uſed to give a crimſon color to vitrified matters. *See* PRECIPITATE *of* GOLD (CASSIUS's).

Oily, thin, ethereal ſubſtances have great affinity with gold. If a light, eſſential oil, and ſtill better if ether, be poured upon a ſolution of gold in aqua regia, and the mixture be ſhook, the gold will be ſeen to paſs into the oily matter, which will float upon the aqua regia now deprived of its metal. This is one of the beſt methods of making potable gold. *See* GOLD (POTABLE).

Neither ſulphur nor fixed alkali can act ſeparately upon gold. But the liver of ſulphur, which is compoſed of theſe two ſubſtances, is alſo a great ſolvent of this metal. This ſolution can be well made only by the dry way. To make it ſucceed, gold-leaves are to be mixed with liver of ſulphur, put into a crucible together, and very quickly fuſed. The gold will be attacked by the liver of ſulphur, and will very ſoon diſappear. If this liver of ſulphur thus impregnated with gold be diſſolved in water, the metal remains ſuſpended, and may be even paſſed through a paper filter.

This is alſo a method of making potable gold, the taſte of which is very diſagreeable, from the liver of ſulphur. Stahl has written a diſſertation concerning this method of diſſolving gold, by which, he thinks, Moſes might have diſſolved and rendered potable the golden calf mentioned in ſcripture *(k)*. As the liver of ſulphur is decompoſed by time, and changes into vitriolated tartar by expoſure to the air, the gold therefore muſt alſo ſeparate from it.

When a ſolution of gold in liver of ſulphur is precipitated by an acid, the ſulphur and gold are precipitated together; and in this caſe the precipitate is not white, as it is from a pure liver of ſulphur, but acquires a yellow color from the gold. The gold and ſulphur thus precipitated together are not united, but are eaſily ſeparable by fire, which conſumes the ſulphur, and leaves the metal pure.

Gold may be allayed with all metals; but theſe allays are not much uſed, excepting with ſilver and copper, for coins and gold plate; with mercury, in the extraction of gold from the ore or matrix containing it, and for gilding; with lead and with regulus of antimony, for its purification by theſe ſubſtances.

Gold allayed with any metallic ſubſtance is always leſs ductile than when pure; which obſervation is applicable in general to all allays. *See* ALLAY.

The color of gold is conſiderably altered and rendered paler by ſilver, and is, on the contrary, much exalted and heightened by a mixture of copper. Cop-

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(*k*) Moſes was probably a good chemiſt, as he had been inſtructed in all the wiſdom of the Egyptians, and poſſibly might have known the ſolubility of gold by liver of ſulphur; but thoſe perſons who cannot be convinced that he was aſſiſted by divine power, in this and all other inſtances of his adminiſtration, will ſcarcely believe that he could perſuade the Iſraelites to ſwallow ſo *fetid*, and perhaps ſo poiſonous a potation, as a ſolution of gold by liver of ſulphur; or that he knew no better method of employing this precious calf, than by applying it as an emetic to his countrymen.

per alſo diminiſhes very little the ductility of gold, and gives it more firmneſs and ſolidity. Accordingly the allay of copper with gold is much uſed.

Gold cannot be ſeparated from ſilver but by expoſing this allay to the action of menſtruums, which can only diſſolve one or the other of theſe two metals, that is, acids and ſulphur. *See* PARTING.

All other metals may be ſeparated from gold by ſcorification with lead, by nitre, and by antimony, or rather by the ſulphur of the antimony. *See the details of all theſe operations, under the words* REFINING, CUPELLATION, PURIFICATION *of* GOLD, *and* SMELTING *of* ORES.

All that we have ſaid concerning the properties of gold ought to make us conſider it as a metal, indeſtructible, fixed, and not to be decompounded. But this does not prove that it is a ſimple body, and abſolutely unalterable. On the contrary, we have reaſon to believe that its reſiſtance to all our operations is owing to our inability to raiſe a ſufficient heat; and that if it were expoſed to a fire infinitely ſtronger, ſuppoſe near the ſun, or even within the ſun, it would be burnt and decompoſed, as the imperfect metals are, in a moderate fire, and perhaps would be reduced into vapors.

Some chemiſts pretend that they have been able to calcine gold. Homberg ſays, in the Memoirs of the Academy of Sciences, that having expoſed gold to the focus of Tſchirnhauſen's great lens, he ſaw this metal ſmoke, and become a glaſs. But according to the tradition preſerved in the Academy, this experiment is not ſufficiently authenticated, and is one of thoſe which require to be repeated with great care. (*l*)

Kunckel ſays, that he changed gold into an irreducible calx, by long calcination, without fuſion, and by reverberation in the manner of Iſaacus Hollandus. This experiment alſo is not very well aſcertained, becauſe no chemiſt has had patience enough to repeat it.

Laſtly, the true alchemiſts do not make any doubt of the poſſibility of decompoſing, or entirely deſtroying gold. Their books are filled with proceſſes by which they affirm, that this metal may be radically diſſolved; its principles ſeparated; its ſulphur, as they call it, its tincture, and its ſoul, may all be extracted.

In Junker's Chemiſtry we find, that Langelot, and Borrichius in his Treatiſe concerning the Wiſdom of Hermes and of the Egyptians, ſay, that if gold leaves be triturated upon a porphyry during fourteen days and nights, the gold will at laſt be changed into a black powder, which contains ſomething viſcous, volatile, of a ſulphureous ſmell, and which being diſtilled with a graduated heat in a ſhallow retort, furniſhes ſome drops of a very red liquor.

This experiment is evidently very long, laborious, and liable to error, as moſt of this kind are. For it is almoſt impoſſible, but that during ſo long a

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(*l*) Homberg ſays, that part of the gold was vitrified, and ſuppoſes only that the reſt might alſo have been vitrified. But he did not aſcertain the purity of the gold which he employed, and therefore the glaſs produced in this experiment might proceed from copper or other metal with which the gold might have been allayed, or from the aſhes of the charcoal which ſupported it; which we find was the opinion of ſome perſons who had been preſent at that experiment.

trituration, a ſenſible quantity of heterogeneous matters ſhould be mixed with the gold, if it were only thoſe which are continually floating in the air. (*m*)

Borrichius ſays alſo in the ſame work, that a plate of gold, being made red-hot and extinguiſhed in water many times, gives an aſtringent taſte to the water, which ſeems to ſhew a kind of ſolution of gold by water. But was the gold, and alſo the water employed by Borrichius in this experiment, perfectly pure? We know with what difficulty gold can be obtained perfectly pure, and that no water but diſtilled water is fit for chemical experiments.

Becker, in his ſecond Supplement to the *Phyſica Subterranea*, gives a proceſs to render gold as ſoft as lead, and to encreaſe its fuſibility. This proceſs conſiſts in throwing melted gold a number of times into a liquor compoſed of ſpirit of ſal ammoniac and rectified ſpirit of wine. I do not believe that this experiment has been repeated by any chemiſt. If it ſucceeds, the ſoftneſs and fuſibility which the gold acquires may probably be cauſed by a ſuperabundance of inflammable principle communicated to it by theſe two liquors.

The author of a treatiſe called *Alchymia Denudata* affirms, that if half an ounce of gold be melted with two ounces of copper, and the copper be afterwards ſeparated from the gold with eight times as much aqua fortis not depurated, and if this work be repeated nine times, the gold will receive ſo lively a red color, that it would ſcarcely be known to be gold, and ſo fixed as to ſuſtain all the ordinary trials without hurt or loſs. This experiment deſerves to be repeated. We do not ſee why the author directs the uſe of undepurated aqua fortis, or of ſuch as probably contains ſome marine acid. Such an aqua fortis ſeems, on the contrary, very unfavorable to the experiment; for as it is a little of the nature of aqua regia, it may diſſolve ſome of the gold.

Roth advances in his Chemiſtry, that gold may be diſſolved in ſpirit of nitre diſtilled in Glauber's manner, the vapors of which have been received and condenſed by highly rectified ſpirit of wine. In this experiment, nitrous ether muſt be formed, and we know that ether has a ſtrong diſpoſition to unite with gold: therefore this ſolution ought to ſucceed better, as the ether is here aſſiſted by the action of the nitrous acid. But this ſolution of gold probably does not differ much from the ordinary tincture of gold made with nitrous ether. *See* GOLD (POTABLE).

Kunckel, in his Chemical Laboratory, propoſes as an excellent ſolvent of gold, but which acts exceeding ſlowly, the ſubtle vapor which ariſes during the re-action of deliquiated fixed alkali with vitriolic acid. This vapor ſeems indeed to be very ſubtle and active, by the impreſſions it makes upon our organs of ſmelling; but theſe qualities are only apparent, and we cannot eaſily be-

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(*m*) Junker alſo relates from Borrichius and Oſiander, that by a long trituration of an amalgam of gold with diſtilled water, a black powder was formed, which was convertible into green glaſs, and that the water became impregnated with a ſaline matter; and that by this method the gold may be deſtroyed. Dr. Lewis obſerves, that the green glaſs probably proceeded from abraded parts of a glaſs mortar, that the ſaline matter had probably pre-exiſted in the water or was extracted from the glaſs, and that the black powder was produced by the trituration of the mercury. The ſame author ſays, that he has triturated an amalgam of gold during a week, without deſtroying any part of the gold.

lieve that this vapor is capable of diſſolving gold, excepting the vitriolic acid be impure and ſulphureous. I collected a conſiderable quantity of this vapor by ſaturating fixed alkali with vitriolic acid in a tubulated glaſs alembic. The vapor when condenſed into a liquor ſeemed to be nothing but pure water. Its poignant ſmell, therefore, ſeems to be nothing but the air which is diſengaged in all theſe efferveſcencies, and which by interpoſing itſelf betwixt the parts of the water, gives this ſpirituous quality to the water, which Mr. Venel has ſhewn to exiſt alſo in the mineral, aerial, and ſpirituous waters. *See* WATERS (MINERAL).

Caſſius, in his Treatiſe *de Auro*, mentions a proceſs to obtain very red cryſtals of gold of a violet ſmell. For this purpoſe he directs gold leaves to be diſſolved by help of a long continued heat, in a liquor compoſed of a pound of the phlegm of ordinary aqua fortis, and of four ounces of common ſalt. When the ſolution is made, the cryſtals above-mentioned may be obtained by cryſtallization, in the ordinary method. As this is merely a ſolution of gold in aqua regia, the peculiar color and ſmell of the cryſtals probably proceed from matters extraneous to this metal. Beſides, marine acid when weakly attached to a baſis without ſmell, always emits an odor ſimilar to that of violets.

Glauber, in his Treatiſe *de Lapide Animali*, gives a proceſs for diſſolving gold, by which alſo it is remarkably altered. This proceſs conſiſts in diſſolving two or three ounces of hartſhorn in an aqua regia made by diſtilling together nitre and decrepitated common ſalt (by means undoubtedly of ſome ſubſtance capable of diſengaging the acids). Then a dram of gold leaf is to be put into this liquor, which is to be afterwards diſtilled off from the gold in a glaſs cucurbit, during which diſtillation the gold is diſſolved; and when the liquor is drawn off, at the bottom of the veſſel, a maſs will be found compoſed of all the ingredients employed. This maſs is then to be fuſed very quickly in a forge fire, and in an open crucible; by which it is changed into a black ſcoria, under which the gold is found rendered white and brittle like regulus of antimony. If this experiment be true, we cannot eaſily conceive why the gold ſhould acquire this whiteneſs and brittleneſs, except we impute it to the mercurial principle of the marine acid; which acid, being retained by the union it forms with the earth of the hartſhorn, may be ſuppoſed capable of a partial decompoſition by the gold and by the fire; and thus a portion of the mercurial principle, which many chemiſts believe to be one of the conſtituent parts of the marine acid, might apply itſelf to the gold, and unite with it ſuperabundantly. Such an experiment well confirmed, would certainly indicate the preſence of the mercurial principle in the marine acid.

As moſt chemiſts have made wonderful experiments on gold, their books are filled with many other proceſſes of this nature, by which very curious and intereſting phenomena reſult, and which therefore deſerve to be repeated. But as they are at the ſame time almoſt always obſcure, confuſed, and full of tedious and embarraſſing operations, they require a very careful examination. Thoſe proceſſes which we have deſcribed as examples of this kind were choſen as the moſt practicable, and which give the moſt hopes of ſucceſs.

Mr. Limburg, who has written a Diſſertation, which obtained the prize from the academy at Rouen, concerning chemical affinities, gives a table of affinities, in which he eſtabliſhes thoſe of gold in the following manner; aqua regia, liver of ſulphur, mercury, ether, ſilver, iron, and lead.

The principal uſes of gold are well known. It is very proper to be formed into coin, and into various ornaments, from its luſtre, beauty, and undeſtructible quality. By means of the art of gilding, much external beauty, neatneſs, and richneſs is given to many utenſils and toys. A fine color alſo is obtained from gold for enamel and porcelain painting. Many perſons have been of opinion, and many ſtill are, that a remedy ſuperior to all others may be extracted from gold, capable of procuring long life. The truth of this opinion is more than doubtful. *See* GOLD (POTABLE). With gold, an exploſive powder more terrible and deſtructive than gun-powder may be made. This powder is called fulminating gold. *See* GOLD (FULMINATING). (*n*)

CCCXLIX. GOLD (FULMINATING). This preparation is gold precipitated from its ſolution in aqua regia. It is called fulminating, becauſe, when it is heated or rubbed ſo as to acquire a certain heat, it makes an exploſion ſimilar and perhaps ſuperior to that of thunder.

The method always uſed to prepare fulminating gold, conſiſts in diſſolving this metal in a ſufficient quantity of aqua regia, which is generally made with ſpirit of nitre and ſal ammoniac; from which the gold is to be afterwards precipitated by adding fixed alkali. A copious precipitate of a yellow and ſomewhat reddiſh color is ſoon formed. This precipitate waſhed and dryed is fulminating gold.

The phenomenon of fulmination is certainly one of the moſt ſtriking and wonderful which chemiſtry affords. The cauſe of this fulmination is not eaſily to be diſcovered. But the following facts may ſuggeſt hints to explain it.

(*n*) For further particulars concerning gold, *ſee the articles* ESSAY *of the* VALUE *of* GOLD; PURIFICATION *of* GOLD *by* ANTIMONY; PARTING; ORES *of* GOLD; GILDING; *and* ALLAY. Every thing almoſt that is known concerning gold, its natural hiſtory, its chemical properties, and its uſe in arts, are treated copiouſly and accurately by Dr. Lewis, in his very uſeful work, intitled, *Philoſophical Commerce of Arts.*

We ſhall here make ſome additions to the metallurgic hiſtory of gold. 1. The color of gold is rendered paler by fuſion with borax; which ſubſtance, or other flux, is uſed to facilitate the fuſion of filings of gold. The paleneſs acquired by gold from borax may be prevented or corrected by fuſion with nitre, or with ſal ammonjac. 2. The color of gold is heightened by an allay of copper, which alſo encreaſes its hardneſs, and when in ſmall quantity, as in the proportion of one to twelve, does not much diminiſh its malleability. Other metals render it paler. *See* ALLAY. See alſo the methods of heightening the color of gilding at the article GILDING. 3. The malleability of gold is diminiſhed by cooling it, when fuſed too haſtily.* To prevent which, artiſts heat the mould into which the gold is to be caſt. 4. The malleability of gold is deſtroyed by fumes of lead and of moſt other metallic ſubſtances; and may be recovered by fuſion with nitre. Many authors ſay that the malleability of gold is injured by the fumes of charcoal, but Dr. Lewis believes this to be a miſtake. 5. Gold may be melted with a low white heat, and when melted has a bright blueiſh green color. Dr. Lewis obſerves, that although its expanſion is leſs than that of other metallic ſubſtances with ſmall degrees of heat, it nevertheleſs expands more than moſt of the other metals when fuſed; and that this property, by which it ſhrinks more when it becomes ſolid than moſt other metals, renders it leſs capable of receiving ſharp and perfect figures, when caſt into moulds, than ſilver, copper, lead, and tin, which do not ſhrink ſo much, and far leſs ſo than iron or biſmuth, which expand in their paſſage from a fluid to a ſolid ſtate.

Firſt, if gold be diſſolved in an aqua regia compoſed of nitrous acid, and of marine acid or common ſalt, and to which no ſal ammoniac is added; and if this gold be precipitated by fixed alkali, this precipitate does not fulminate. On the contrary, it fulminates ſtrongly, if it be precipitated from this ſame aqua regia by a volatile alkali. Theſe facts were well known to chemiſts. One of the menſtruums employed by them to diſſolve gold, is the liquor which they call *menſtruum ſine ſtrepitu*; this ſolvent is a compound of equal parts of alum, nitre, and common ſalt, with which the gold is firſt to be ground; water is then to be added, and the whole digeſted, that the ſalts may act upon the gold. By this method the gold is found to be entirely diſſolved. In this operation the vitriolic acid of the alum diſengages the acids of the nitre and of the common ſalt, and thus an aqua regia is formed, in which no ſal ammoniac, and conſequently no volatile alkali, enters. Hoffman and Etmuller affirm, that if gold be precipitated by a fixed alkali from its ſolution in this menſtruum ſine ſtrepitu, this precipitate of gold does not fulminate, but that it fulminates ſtrongly when the precipitate is made by volatile alkali.

Secondly, when gold is diſſolved in an aqua regia in which ſal ammoniac enters, its precipitate, whether by a fixed or by a volatile alkali, always fulminates.

Thirdly, when fulminating gold is prepared, and all the precipitate carefully collected, we find that its weight ſenſibly exceeds that of the gold employed; that is, a fourth more of fulminating gold is obtained, than the gold which was diſſolved.

Fourthly, ſulphur, or vitriolic acid, or fixed alkalis, being well mixed with fulminating powder, deprive it of its fulminating quality.

The firſt and ſecond of theſe experiments prove clearly, that in order to procure fulminating powder, a nitrous ammoniacal ſalt muſt be formed in the operation. The augmentation of the weight of the gold ſhews alſo that this ammoniacal nitrous ſalt applies itſelf to the gold during the precipitation, and incorporates with it.

Laſtly, the methods, by which the fulminating property of this precipitate may be deſtroyed, are alſo capable of decompoſing the nitrous ammoniacal ſalt. The acid of ſulphur, or vitriolic acid, ſeparates its nitrous acid, and forms a vitriolic ammoniacal ſalt, by uniting with its volatile alkali; and the fixed alkali diſengages its volatile alkali, and forms ordinary nitre with its nitrous acid.

All theſe facts ſeem to prove, that the fulminating property of the gold is occaſioned by the nitrous ammoniacal ſalt formed during the precipitation, and which very ſtrongly and intimately unites with the metal. Further, this nitrous ammoniacal ſalt is known to be ſuſceptible of detonation when heated to a certain degree, and without addition of any combuſtible matter, which property is occaſioned by the quantity of inflammable matter which its volatile alkali contains. This detonation of nitrous ammoniacal ſalt is indeed very ſmall, when compared with that of fulminating gold. But all exploſive bodies are known to produce exploſions ſo much the ſtronger as they are more confined and compreſſed. But the parts of the ammoniacal ſalt may be ſo combined with the gold as to be ſtrongly included within the particles of the metal.

If the exploſion of the fulminating gold only proceeds from the detonation of the nitrous ammoniacal ſalt which it contains, as we have reaſon to believe, it muſt certainly be the effect of the inflammation of the nitrous ſulphur, in which chiefly conſiſts the detonation of nitre. *See* DETONATION *of* NITRE.

Mr. Beaumé has a particular opinion on this ſubject. He thinks that the nitrous ſulphur which occaſions the fulmination of gold, is formed during the precipitation, by the union of phlogiſton with nitrous acid; that this nitrous ſulphur exiſts mixed with the gold, and ready formed before its fulmination; and conſequently that the nitrous ammoniacal ſalt does not contribute to the production of this effect.

The chief proof which he brings to ſupport this opinion, is, that if fixed alkali be poured upon fulminating gold, no ſmell of volatile alkali ariſes. Mr. Beaumé further affirms, that fulminating gold may be boiled in any quantity of water, provided that water be pure, that is, diſtilled, without loſs of its fulminating quality; which experiment ſeems to ſhew, that the fulminating quality is not occaſioned by any ſaline ſubſtance ſoluble in water, as the nitrous ammoniacal ſalt, but rather by ſome ſubſtance inſoluble in water, as the nitrous ſulphur probably is, from its analogy to vitriolic ſulphur. This is certainly an ingenious thought, and we wiſh that Mr. Beaumé would proſecute, prove, and explain it fully, as it deſerves. *See* SULPHUR (NITROUS).

But whatever be the cauſe of the fulmination of gold, we are certain that the exploſion occaſioned by it is one of the moſt violent which are known in chemiſtry. It is not neceſſary that fulminating gold ſhould be touched by an ignited matter, or that it ſhould be heated till it becomes red, to make it explode. The heat requiſite for this purpoſe is intermediate, betwixt that of boiling water and the heat which makes metals of an obſcure red color. Friction alone, and even a friction not very conſiderable, is ſufficient to make it fulminate; and this effect is produced either in open or in cloſe veſſels. Theſe circumſtances render fulminating gold very dangerous. Several chemiſts, from not ſufficiently knowing its effects, have been hurt or killed, while they were pounding and drying it. I was witneſs to the following accident. A young man, who worked in a laboratory, had put a dram of fulminating powder into a glaſs bottle, and had neglected to wipe the inner ſurface of the neck of the bottle, to which ſome of the powder adhered. When he endeavored to cloſe this bottle, the turning the glaſs ſtopper round, to make it fit more cloſely, occaſioned ſuch a friction, that heat enough was produced to make part of the powder explode. By this exploſion the young man was thrown ſome ſteps behind, his face and hands were wounded by the fragments of the bottle, and his eyes were put out. Notwithſtanding the violence of this exploſion, the whole dram of fulminating gold did certainly not explode. Probably even very little of it was exploded, for much of it was afterwards found ſcattered about in the laboratory, in its unexploded ſtate.

A miſfortune of this kind is ſo terrible, and at the ſame time ſo difficult to be prevented by thoſe who are not ſufficiently initiated in chemiſtry, that I thought a relation of this accident ought to be publiſhed.

The gold is not altered by this ſudden and violent inflammation. Of this we may be aſſured by detonating ſo ſmall a quantity of fulminating gold under a glaſs bell, that nothing is to be feared from the exploſion. The gold may be afterwards obſerved to adhere, in its proper metallic ſtate, to the inner ſurface of this bell. (*o*).

CCCL. GOLD (POTABLE). Alchemiſts have always believed that gold poſſeſſes admirable virtues for the cure of many diſeaſes, and for the prolongation of life. They have conſequently laboured much to procure remedies from this metal, and they have accordingly invented many preparations, any one of which, if we believe the inventor, is capable of curing all evils. But the conſtant obſervation of the moſt intelligent practitioners not having confirmed theſe pretended qualities, this metal is not employed by phyſicians. Many ignorant people have ſtill the prejudice of its great virtues; and empyrics, who know how to profit by the weakneſs of men, keep up and ſtrengthen this prejudice, by continually boaſting of their elixirs and tinctures of gold, and of their potable gold, which they always declare to be wonderful ſecrets.

The indeſtructible quality of gold ſufficiently ſhews, that no effect can be produced upon it in our body, for we are certain that it is voided unaltered; and it is only uſed in pharmacy to cover and conceal other remedies, or to give them an air of wealth and grandeur which pleaſes ſome people.

This inactivity of gold in its natural ſtate, ſeems to be acknowledged by the moſt ignorant, for all the quacks who boaſt of their golden remedies declare that they can radically diſſolve it. But this pretenſion is as uſeleſs to an intelligent phyſician as it is ill-founded, ſince the example of many other metallic matters, the virtues of which are aſcertained, although they are not diſſolved radically, proves that ſuch a ſolution of gold, ſuppoſing even that this metal had virtues, would be very unneceſſary. Accordingly when we examine the preparations given for potable gold, we find that a part of them contains no gold, and the gold which others do actually contain may be eaſily extracted, and reduced to its natural ſtate.

(*o*) The expanſion of fulminating powder ſeems to be more ſudden and quick, but leſs forcible than that of an equal quantity of gunpowder. The quickneſs of the expanſion of fulminating gold, is inferred from the loudneſs of its exploſion, which is much greater than that of gunpowder; and from its perforating or impreſſing a metalline plate, upon which it is laid unconfined, and is exploded; which effect is not produced by gunpowder; the cauſe of which ſeems to be, that the force of the exploſion of gunpowder is applied ſo ſlowly and gradually, that it may be communicated from the part of the plate which the powder touches to the other parts of the plate, and thus the force is reſiſted by the vis inertiæ of the whole plate; whereas in the exploſion of fulminating gold, the whole force is ſo ſuddenly applied to the contiguous part of the plate, that it is capable of perforating or impreſſing that part before it can be communicated to the reſt of the plate. Now, though the force applied during the inſtant of the exploſion of fulminating gold, be greater than the force of exploding gunpowder during that inſtant, yet the ſum of the forces of exploding gunpowder, in the ſeveral inſtants of its exploſion, is probably much greater than the whole force of fulminating gold, becauſe a quantity of aurum fulminans ſhut up in a ſtrong hollow iron ball, and heated in the fire, did not ſeem to explode; while gunpowder treated in the ſame manner burſt the ball. This experiment is related in *Dr. Birch's Hiſtory of the Royal Society*, vol. I.

Dr. Black attributes the encreaſe of weight, and alſo the explosive property of fulminating gold, to adhering fixable air. *See his eſſay on quicklime*, amongſt the *Eſſays phyſical and literary*, publiſhed at Edinburgh, vol. II.

To render gold potable, it muſt be previouſly diſſolved. This may be done in aqua regia, or even in any of the acids, with proper management; but by this method gold and the other metals are rendered corroſive. This is ſo well known, that the preparers of potable gold affirm that their ſolutions are made without any acid. But as all the very thin and volatile oily ſubſtances have a ſtrong diſpoſition to unite with gold, and do really unite with it when they find it much divided, by their means may be made ſeveral tinctures of gold, or kinds of potable gold. If theſe preparations do not acquire any virtue from the gold which they contain, they have at leaſt that of the inflammable ſubtile matter, which is the vehicle of the gold. *See* OILS (ESSENTIAL) *and* ETHER.

Subtile eſſential oils, ethereal liquors ſuch as the vitriolic and other ethers, being mixed and agitated with a ſolution of gold in aqua regia have a property of depriving this aqua regia of its gold, which it ſeizes, ſo as to carry it to the ſurface of the liquor, where it floats upon the aqua regia. Many receipts for potable gold are upon theſe principles. One of theſe is in the Diſpenſatory of the Faculty of Medicine in Paris. It conſiſts in mixing and agitating ſixteen parts of eſſential oil of roſemary with one part of gold diſſolved in aqua regia, in ſeparating afterwards this aqua regia thus deprived of gold from the eſſential oil which contains it, and in diſſolving this eſſential oil in five times its weight of rectified ſpirit of wine. This preparation is the ſame as that deſcribed in the laſt edition of Lemery's Chemiſtry, under the name of *potable gold of Mademoiſelle Grimaldi*. As all eſſential oils have the ſame property of taking gold from the aqua regia, potable gold may be made with any of theſe, as well as with the oil of roſemary.

As ether poſſeſſes eminently all the properties of the moſt attenuated and volatile oils, it produces the ſame effect, and better than eſſential oils, upon the ſolution of gold; ſo that potable gold may be made by any of the ethers in the ſame manner as by the eſſential oils. Mr. Pott having perceived a ſmell of ether in a potable gold, ſold under the name of *Drops of General de la Motte*, imagined that this preparation was made with ether. But as theſe drops are miſcible with water in any proportion, a quality which does not belong to pure ether, this ſmell of ether probably proceeds from a ſmall quantity of nitrous ether formed by the mixture of the nitrous acid of the ſolution of gold with ſpirit of wine, both which are certainly ingredients in this preparation.

All theſe tinctures of gold are nothing but gold in its natural ſtate, exceedingly divided, and ſuſpended in an oily liquor. They are not therefore, properly ſpeaking, tinctures. Neither can they be called potable gold in any other ſenſe than that it ſwims in a fluid, and is divided into ſo fine parts, that it may be drank under the appearance of a liquor, as Mr. Baron well remarks in his edition of Lemery.

We ought to obſerve, that all theſe preparations we have mentioned contain a certain quantity of the acids of aqua regia; and that they are, notwithſtanding, apt to depoſite in time a conſiderable quantity of the gold they contain, unleſs the contained quantity be very ſmall. Gold is depoſited, particularly from the mixture of ether, in its metallic ſtate, and is even very brilliant.

Laſtly, as gold may be diſſolved and reduced into a liquor, as well by liver of ſulphur as by aqua regia, a potable gold may alſo be made by that ſolvent. Nevertheleſs we have not ſeen any potable gold made in that manner, probably from the inſupportable ſmell and taſte of the liver of ſulphur.

CCCLI. GRAIN. A grain is the ſmalleſt weight uſed in the ordinary operations of chemiſtry. It is nearly equal to the weight of a grain of corn, from which it has received its name. A grain is the 24th part of a ſcruple, $\frac{1}{72}$ part of a gros, the $\frac{1}{576}$ part of an ounce, &c. (*p*).

CCCLII. GRAINS. The ſeeds of moſt vegetables are ſo called. Two principal kinds of ſeeds are diſtinguiſhed in chemiſtry, relatively to the predominant ſubſtances which are obtained from them. Some of them contain at the ſame time a conſiderable quantity of mucilage and oil, which may be ſeparately extracted from them; the former by infuſion in water, and the latter by expreſſion, or both together by trituration with water, in form of an emulſion. Theſe are therefore called emulſive grains or ſeeds. Of this kind are almonds, and the ſeeds of almoſt all fruits. The other grains are called farinaceous, becauſe they contain no ſuperabundant oil like the former, but are entirely compoſed of a dry ſubſtance eaſily reducible into a fine powder, called meal, from which water can extract a large quantity of mucilaginous, nutritive, ſaccharine matter, and which is very ſuſceptible of the ſpirituous fermentation. Of this kind are the grains of all gramineous and leguminous plants, the fruits of which are only coverings including grains.

CCCLIII. GRANITE. A granite is a ſtone formed by the coheſion of ſmall ſtones of different colors, and of different natures.

This diſpoſition conſtitutes it a ſtone compoſed of ſmall particles, called grains; and hence it is called granite.

Moſt granites are formed by particles of quartz, ſpars, ſand, and mica or talk, of different colors. As quartz and ſand generally predominate in granites, theſe ſtones ſtrike fire with ſteel, and are claſſed amongſt the hard ſtones. Nevertheleſs, granites differ much in this reſpect. Granites are found in large maſſes. Some of them are very beautiful, when cut and poliſhed. Many beautiful granites are found in Brittany. The moſt valuable granites are brought from Egypt. (*q*).

CCCLIV. GRANULATION. Granulation is an operation by which metallic ſubſtances are reduced into ſmall grains or roundiſh particles, the uſe of which is, to facilitate their combination with other ſubſtances.

This operation is very ſimple. It conſiſts in pouring a melted metal ſlowly into a veſſel filled with water, which is, in the mean time, to be agitated

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(*p*) The weights mentioned in the text are French. A grain is $\frac{1}{29}$th part of an Engliſh troy pennyweight, or $\frac{1}{585}$th part of a troy ounce. *See the article* WEIGHTS.

(*q*) Granites are very various in their appearance, as they are in the colors and proportions of their component particles. Theſe particles conſiſt of common quartz, of that ſpecies of quartz called *feltſpar* or rhomboidal quartz, and of mica, with which alſo are often accidentally mixed particles of other ſtones, as of ſteatites, baſaltes, garnets, and metallic earths. The rocky ſummits of the higheſt mountains generally conſiſt of this compound ſtone, or of porphyry, which is alſo a compound ſtone, and different from granite only in containing, beſides quartz, feltſpar, and mica, a great deal of the opake colored ſiliceous ſtone called jaſper.

with a broom. Lead is alſo granulated by pouring it when melted into a box, the internal ſurface of which is to be rubbed with powdered chalk, and by ſhaking ſtrongly the box, till the lead has become ſolid. What paſſes in theſe operations may be eaſily imagined. Metals are granulated becauſe their ductility renders them incapable of being pounded, and becauſe filing is long, tedious, and might render the metal impure by a mixture of the iron of the file. (*r*).

CCCLV. GRAVITY. Gravity is the property of bodies, by which they endeavor to approach each other. Thus, for example, we know that a body reſting upon the earth cannot be raiſed but by a force ſuperior to what is called its weight; and that this body thus raiſed, returns precipitately to the earth, when it is no longer ſupported Men in general have always obſerved this phenomenon without attending to it. But philoſophers have always admired it, and have endeavoured to diſcover its cauſe, but without ſucceſs; which is not ſurpriſing; for we do not yet know all the circumſtances attending gravity. We are not yet certain, that all the particles of matter have this property. The gravity of the air was not diſcovered till the laſt age. We will not therefore attempt to reaſon upon this obſcure ſubject. But as the particular effects of gravity influence much all chemical phenomena, and as the particular gravity of the integrant parts of different ſubſtances is probably the primary cauſe of the action of theſe ſubſtances upon each other, we muſt enter into ſome detail upon this ſubject.

The gravity of a body may be conſidered in two manners. Firſt, every body, conſidered as heavy, cannot be compared but to greater or leſs quantities of the ſame kind of matter. In this caſe, we may obſerve that the greater the quantity of matter of any body is, the greater is the effect of its gravity. Hence the gravity of bodies is directly as their maſſes or quantities of matter. The gravity of bodies conſidered in this view is called their *abſolute gravity*, that

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(*r*) The granulation of metals by agitation in a box, is thus explained by Cramer. The metals capable of this kind of granulation, as lead, tin, and braſs, are very brittle, when they are ſo hot as to be almoſt fuſed. The chalk with which the inſide of the box is rubbed, encreaſes the reſiſtance to the motion of the agitated metal, and preſerves the box from being burnt. When the melted metal is ſhaken and daſhed againſt the ſides of the veſſel, it no ſooner becomes ſolid, and conſequently exceedingly brittle, than it is ſhivered into a fine duſt. Thoſe metals which are rendered more tenacious by being heated almoſt to fuſion, as gold and ſilver, muſt evidently be incapable of this kind of granulation.

The other method of granulation may be performed by pouring the metal upon a broom, interpoſed betwixt it and the water, by which means the fluid metal is divided into ſlender ſtreams which are further broken by the circular motion of the water. See a deſcription of an apparatus for granulating copper for the purpoſe of making braſs, in a note to the article BRASS. Melted metals may alſo be granulated by being poured from a certain height into a veſſel of water, or of other fluids capable of fixing by their coldneſs the drops as ſoon as they fall, and thereby preventing them from again running together into large maſſes. This granulation may be thus explained. The ſeveral parts of a fluid poured out of a veſſel, begin their falls at ſucceſſive inſtants of time. The velocity acquired by each of theſe parts from the accelerating power of gravity, is proportionable to the time from the beginning of its fall. This acceleration of velocity produces a continual increaſe of the interval or ſpace betwixt any two parts of a fluid, which have begun to fall at different times. Hence the ſeveral parts of a falling fluid tend to ſeparate from each other, or to form diſtinct maſſes or drops: and they accordingly do ſeparate, when this tendency is ſtronger than the force of coheſion by which they are held together.

is, their weight, or the conſtant effect of the gravity of any certain quantity of matter. Thus we judge, that the quantities of any two ſubſtances, however diſſimilar, are equal, if they produce equal effects of gravity. The weight, therefore, and the quantity, of a ſubſtance are the ſame thing. Men have agreed to determine the weights and quantities of matter of all ſubſtances by certain effects of gravity, and have given different names to more or leſs conſiderable weights, as *grains*, *drams*, *ounces*, *pounds*, &c. ſo that two quantities of different ſubſtances, which produce the ſame effect of gravity, that is, of a grain, or of a dram, of an ounce, &c. are juſtly conſidered to be equal. In this ſenſe we ſay, that a pound of lead is not heavier than a pound of cotton. This abſolute gravity, weight, or quantity of matter of any body, is meaſured by means of an ordinary ballance, which is a lever ſuſpended freely on its center of gravity, which ought to be exactly in the middle of its length. Two quantities of matter, being ſuſpended at the two extremities of the lever, are conſidered as equal, or of the ſame weight, when this lever maintains itſelf in an horizontal direction.

This is the beſt and juſteſt method to determine the quantity of matters employed. It is much uſed in commerce, and in the ordinary purpoſes of life. It is alſo the only one which ought to be employed in all the operations of chemiſtry, which require accuracy.

In the ſecond place, we may conſider a body as heavy, relatively not only to its maſs or quantity of matter, but alſo to the ſpace it occupies, that is, to its bulk. A great difference is found in this reſpect, among natural bodies. This difference proceeds from the greater or leſs number or ſize of empty ſpaces, called pores, which are in every body. Bodies which are not very porous, muſt evidently contain under the ſame bulk, a greater quantity of matter than thoſe which are more porous; and conſequently a body of a certain ſize, but not very porous, muſt have a greater abſolute gravity than another body of the ſame ſize, but more porous. As theſe differences depend on the particular ſpecies of each body, gravity eſtimated in this manner is called *ſpecific gravity*. It may alſo be called *relative*, becauſe we judge of it by comparing bodies with one another. This gravity is the ſame thing as the denſity of bodies. The ſpecific gravity or denſity therefore of bodies, conſiſts in the relation betwixt their abſolute gravity or weight and their bulk; and the ſpecific gravity of any body is ſo much greater as its abſolute gravity is more conſiderable, and as its bulk is leſs; or, in the language of geometricians, it is in a direct ratio of the maſs, and in an inverſe ratio of the ſize. Hence if two bodies be equal in ſize, they will be to each other as their real weights or maſſes: and if they are equal in weight or maſs, their ſpecific gravities will be reciprocally as their ſizes; that is, the ſpecific gravity of the leſs bulky body will ſo exceed that of the more bulky body, as the bulk of this latter body exceeds that of the former.

As the denſity of bodies is one of their internal and eſſential qualities, the knowledge of which contributes much to diſtinguiſh them, and to throw light upon their nature, philoſophical chemiſts have always applied themſelves to determine this matter. By this method the purity of metals, and of ſeveral other ſubſtances, the degree of concentration of acids, of liquid alkalis, of ſpirits, and of other ſolvents, may be aſcertained; and thus important diſcoveries may be made. For inſtance, they have diſcovered that by allaying metals and ſemimetals, metallic maſſes are formed, the ſpecific gravity of which ſeldom correſponds with what it ought to be, if theſe metals were not condenſed or expanded by the allay. Theſe experiments, however, are but yet begun; and we may preſume that in proſecuting them, the ſame phenomena will be obſerved, and perhaps ſtill more varied in the ſolutions and combinations of all other ſolid and liquid bodies, and that we may find by this means explanations of many obſcure and intereſting facts.

The ſpecific gravity of bodies may be conveniently determined by ſeveral methods. As this gravity is only relative, and can be eſtimated by compariſon only, a ſubſtance ſimple and invariable, or which at leaſt might eaſily be made as pure as poſſible, was judiciouſly choſen, to the weight of which the weight of all other ſubſtances might be compared. All theſe conditions are found in pure and diſtilled water. Accordingly by weighing very accurately a determinate quantity, an ounce, for inſtance, of pure water in a phial, and marking preciſely the ſpace it occupies in the phial, the relation of the ſpecific gravity of any other fluid to the ſpecific gravity of this water may be eaſily determined. For this purpoſe, let ſuch a quantity of this fluid be put into the phial, that it ſhall exactly occupy the ſame ſpace which the water did, and let it be accurately weighed. As the bulk of the two ſubſtances thus compared are equal, and as their ſpecific gravities are to each other in this caſe as their abſolute weights, if the liquor compared with water weighs exactly an ounce, its ſpecific gravity will be equal to that of water; and if, on the contrary, it weighs more or leſs than an ounce, its ſpecific gravity will be ſo much more or leſs great than that of water, according as it ſhall weigh more or leſs than an ounce. If, for example, this bulk of liquor equal to that of an ounce of water, weighs two ounces, its ſpecific gravity will be double that of water; if, on the contrary, this liquor weighs only half an ounce, its ſpecific gravity will be only half as much as that of water.

This method is very juſt, convenient, and the beſt which can be employed to determine the ſpecific gravity of liquid ſubſtances, from the facility with which they may be all reduced to an equal bulk. But ſome management and addreſs are requiſite to give preciſely the ſame bulk to two ſolid bodies. To do this preciſely we may even affirm to be impoſſible; therefore another method muſt be uſed, to determine the ſpecific gravities of ſolid bodies. We have obſerved, that the ſpecific gravities of bodies of equal bulk are to each other as their abſolute gravities or weights, and upon this principle the method we have explained is founded; but that when the maſſes or weights of two or more bodies are equal, their ſpecific gravities are to each other in the inverſe ratio of their bulks. From this ſecond principle we may more eaſily determine the ſpecific gravities of ſolid bodies. The method uſed for this purpoſe conſiſts in reducing the bodies to be compared to the ſame equal weight, and then in comparing their bulks to each other, or (which is the ſame thing) the effects of theſe bulks upon the ſame or equal quantities of water, as we ſhall ſee.

When, therefore, the ſpecific gravity of two ſolid bodies is to be determined, an equal quantity, an ounce, for example, of each of them is to be weighed very accurately in the ordinary method, whatever be the difference of their bulks. Each of theſe bodies is afterwards to be weighed in pure water, by the *hydroſtatical ballance*, and the difference between their real weights and their weights when they are immerſed in water, that is, the loſs of weight which each of them ſuſtains by this immerſion, is to be obſerved. Theſe loſſes of weight are then to be compared; and the body which has loſt the leaſt exceeds the other in ſpecific gravity in the ſame proportion that the loſs of weight of the latter exceeds that of the former.

To underſtand well what happens in this experiment, we muſt remark, that if a ſolid body be immerſed in water, and if it be left in the water unſupported, and without giving it any impulſe, the bulk of this body will occupy the room of a quantity of water exactly equal in bulk to that of the immerſed body; and if the ſpecific gravity of this body be equal to that of the water, it will remain motionleſs in the ſame place where it was left, becauſe its real weight being the ſame as that of an equal bulk of water, it remains ſuſpended in the water, like an equal quantity of water, that is, counterpoiſed by the gravity of all the ſurrounding parts, and conſequently at reſt, and in an equilibrium. But if the ſpecific gravity of this body be different from that of water, then no equilibrium can exiſt. If its weight be greater than that of the water, it muſt neceſſarily deſcend to the bottom of the veſſel; and if it be leſs, it muſt riſe to the ſurface of the water: and the force with which that body will riſe or deſcend, will be proportionable to the difference betwixt its gravity and that of water. If, for example, when it occupies the place of an ounce of water, it really weighs two ounces, it will fall to the bottom of the veſſel, but with a force only proportionate to the exceſs of its weight above the weight of water; for as it cannot fall without continually diſplacing the bulk of an ounce of water, therefore one ounce of its weight will be employed in ballancing or counterpoiſing an equal weight of water, and the body will deſcend by the effect of the weight of the remaining ounce, or with half its real weight. Hence, if that body be ſuſpended at one of the arms of a ballance, it may be counterpoiſed by an ounce weight, placed in the ſcale ſuſpended by the other arm of the balance, in air, and conſequently it will appear to be one half leſs heavy in water, than in air.

This being eſtabliſhed, as a body of a determinate weight loſes ſo much leſs of this weight in water as its bulk is leſs, and as theſe two things are in the ſame relation, we may therefore ſubſtitute one for the other; and when we weigh in water two bodies of equal weight, we may judge of the relation of their bulks, and conſequently may appreciate their ſpecific gravities, by determining and comparing the diminution of weight which they ſuſtain when weighed in water. This is much more eaſy and exact than a menſuration of their bulks. Thus, for example, if we weigh in water two bodies of equal weight, and if the one loſes a tenth part of its weight in the water, and the other loſes only a twentieth part, we may conclude from thence, that the bulk of this latter body is one half leſs than that of the former, and conſequently its ſpecific gravity is double; becauſe the ſpecific gravities of bodies of equal weights are in the inverſe ratio of their bulks. *See what ought to be obſerved in weighing bodies in water, under the article* BALANCE (HYDROSTATICAL).

From what has been ſaid concerning the gravity of bodies, we may perceive, that in examining their nature and properties, the ſpecific gravity only of bodies is attended to; and that the abſolute gravity, or rather the weights uſed to determine it, are things arbitrary and conventional, which, however, determine well the abſolute gravity, when they themſelves are determinate and accurate. But we muſt obſerve, that weights, like meaſures, have a great inconvenience in not being uniform. They are fixed arbitrarily and differently in different countries; ſo that an ounce, or a pound, is not always the ſame in one country as it is in another; which neceſſarily introduces confuſion and errors in commerce and in the arts. As weights cannot be fixed but by an exact meaſure or bulk of the bodies intended to be uſed to fix theſe weights, the meaſures muſt evidently be firſt rendered uniform in all nations, which is not to be expected. The thing, however, is very poſſible. The length of a pendulum, which vibrates every ſecond under the equator, is a fixed and invariable meaſure to which all others may be referred, and would be very proper to be univerſal, if nations would agree to it. This project, the execution of which would certainly be very favorable to commerce, arts, ſciences, and conſequently mankind, was propoſed by M. de la Condamine, in a memoir which he read at the Academy of Sciences.

To compleat this article, we muſt examine what effects are produced by the gravity of bodies in their combinations and decompoſitions, that is, in all chemical operations. It is undoubtedly the moſt important and deciſive object for the general theory of chemiſtry, but it is not within our province, as it cannot be well treated but by help of mathematics. In this point theſe two ſciences, which appear ſo remote from each other, meet. A man ſufficiently intelligent and able in both, might, by treating this matter accurately, throw much light upon it, and lay the foundation for a new phyſico-mathematical ſcience; or rather, might render the application of algebra and geometry to natural philoſophy much more general. Several perſons, and lately Mr. Sage, in a Diſſertation, which gained the prize of the Academy of Rouen, concerning the Cauſe of Chemical Affinities, have advanced ſome ſteps in this path; but great difficulties will probably occur. Perhaps chemiſtry is not yet ſufficiently advanced to be ſubjected to calculation; perhaps even it will never be ſo far advanced; and although men of genius have, ſince the reſtoration of the ſciences, carried mathematics to a greater perfection than it was believed could have been attained, the problems which chemical phenomena offered to geometricians may be ſo complicated, as to be above the reach of human underſtanding.

However that may be, in theſe latter ages a moſt happy application has been made of the theory of univerſal gravity to the ſyſtem of the world, and to explain very ſatisfactorily the celeſtial phenomena. If this univerſal gravitation of the heavenly bodies, ſo happily obſerved, and ſo well calculated, be an eſſential property of matter in general, as many reaſons induce us to believe, its effects cannot be confined to very large bodies ſeparated from each other by immenſe diſtances, but muſt neceſſarily act between the ſmall particles of matter at very ſmall diſtances from each other, and conſequently in chemical combinations and ſolutions. Although we do not preciſely know the bulks, the maſſes, the forms, nor the diſtances of the integrant and conſtituent parts of bodies, we ſee them act upon each other, unite or ſeparate, adhere more or leſs ſtrongly, or reſiſt all union; and we muſt believe that theſe effects are produced by the ſame power; ſuch, for example, as the reciprocal gravitation of theſe ſmall particles to each other; which is variouſly modified, according to their ſize, their denſity, their figure, their extent, the intimacy of their contact, or the greater or leſs diſtance of their approach.

By teleſcopes and other inſtruments, aſtronomers have indeed diſcovered the ſize, diſtance, and motions of heavenly bodies; and by applying calculation and geometry to theſe diſcoveries, they have perceived the gravitation of theſe great bodies, and have even determined the law of that gravitation: but the microſcope has been found ineffectual to ſhew the primary and elementary parts of bodies; and when geometricians have endeavoured to apply the theory of univerſal gravitation to the phenomena of terreſtrial bodies, they found that this gravitation did not follow the rule of the inverſe ratio of the ſquare of the diſtance, when this diſtance was very ſmall. The law of gravitation in ſmall diſtances does not appear to have been yet well determined; whether this proceeds from a want of a ſufficient number of facts, or becauſe it has not been examined by the ableſt geometricians. But although we cannot preciſely determine this point, would it not be deſirable to approximate it indirectly, and by making ſuppoſitions? This appears ſo much the more eaſy, as the velocities, the times, the ſpaces paſt, need not be obſerved and calculated, nor periodical revolutions to be determined: for the motions of the elementary parts of bodies, although certainly very regular, and ſubjected to the ſame fixed laws, cannot be perceived minutely, and only by their effects. They are made in indiviſible inſtants. They are not conſtant, but perpetually variable, according to the circumſtances which determine them. We cannot therefore conſider theſe objects but in general, or rather in a vague manner. But, however, I aſk thoſe who are capable of deciding ſuch queſtions, if, ſuppoſing that the ſmalleſt atoms of matter are affected by the ſame power by which the heavenly bodies gravitate to each other; may we not conſider their tendency to the center of the earth as of no effect, when we attend to the almoſt infinite ſmallneſs of theſe elementary particles, and the infinitely ſmall diſtance at which they may approach each other? The effect of their gravity ought in this caſe to be, to make them tend to each other. They are, as it were, ſmall worlds ſeparated from the reſt; or, being at liberty to yield to their reciprocal tendency, they re-act upon each other, without being diſturbed by the great counterpoiſe which keeps the whole univerſe in an equilibrium. In the ſecond place, as the diſtance betwixt theſe molecules of bodies is infinitely ſmall, or none at all, may not contact be ſubſtituted for it? And in this caſe, would not the force with which theſe molecules tend to each other, or adhere together, be in a compound ratio of their denſities and contacts? Hence it ſhould follow, that bodies whoſe primary integrant molecules ſhould have the greateſt denſity, and whoſe figure ſhould allow them to have the moſt extenſive and immediate contact, would be the hardeſt of all bodies, or thoſe whoſe aggregation would be the firmeſt; ſuch, for example, as we conceive that of vitrifiable ſtones to be: and that, on the contrary, bodies whoſe primary integrant molecules ſhould have the leaſt denſity, and ſuch a figure that they could not have but the ſmalleſt poſſible contact, would be the leaſt hard of all bodies, or rather would be fluid; ſuch pure fire appears to be, and the other ſubſtances eſſentially fluid, if any ſuch are.

In the third place, if we ſuppoſe ſubſtances whoſe primary integrant molecules have a very great denſity, but can have only very ſmall contacts; whether that may depend on their figure, or the interpoſition of ſome other ſubſtance with the parts of which they can alſo have but ſmall contacts; then we may evidently perceive, that the force with which theſe molecules tend to unite together will not be ſatisfied, and conſequently will be in a continual niſus or effort, and, if we may be allowed to ſay it, in a ſtate of violence; ſo that when they ſhall have within their reach any other ſubſtance upon which they may exerciſe the tendency which they have to unite with that ſubſtance; that is, with which they ſhall have a greater contact; they will then actually unite with that ſubſtance with an activity and impetuoſity proportionate to their remaining tendency to unite, or their unſatisfied gravitation. Such appear to be mineral acids, and in general all chemical ſolvents; the action of which cannot be conceived, unleſs we ſuppoſe that the force with which their integrant parts tend to unite with the particles of the bodies which they diſſolve, is much greater than the force with which theſe latter are kept united.

Hence, if the parts of the diſſolved body be ſo denſe, or be capable of having ſuch contact with the parts of the ſolvent, that the activity of theſe latter parts ſhall be entirely ſatisfied by their mutual union; the ſolvent will then be in a ſtate of reſt, or in a kind of equilibrium, and will have no more diſſolving power. This is called in chemiſtry the *ſtate or point of ſaturation.* To make this ſaturation compleat, each of the integrant parts of the ſolvent muſt have met an integrant part of the diſſolved body, upon which it may exhauſt all its activity.

If, on the contrary, the parts of the diſſolved body be not ſufficiently denſe, and cannot have a ſufficient contact with the parts of the ſolvent to ſatisfy entirely all the tendency of theſe latter; from ſuch a combination, an imperfect ſaturation only of the ſolvent will reſult, and it will ſtill retain force enough to act upon other bodies. This may be obſerved in the neutral deliqueſcent ſalts, and other combinations of this nature. *See* SALTS, *and* DELIQUESCENCE.

Fourthly, we may perceive from what has been ſaid, that the force which makes the integrant and conſtituent parts of bodies tend to each other, although much ſuperior to their gravitation towards the center of the earth, is however limited; that it muſt be very variable in its effects, and even of no effect in certain circumſtances. In the ſame manner as the adherence of the integrant parts of a body which yields to the action of a ſolvent, ought not to be conſidered as any thing in compariſon of the force which makes them tend to the parts of this ſolvent; ſo that after the ſolution they cannot any longer be united together, but only to the parts of this ſolvent; ſo in the ſame manner, I ſay, we may conceive that the force which unites the principles of a compound body to each other ought to become ineffectual, when, on one ſide, the tendency of the parts of theſe principles is entirely exhauſted by their union; and when, on the other ſide, to this compound is applied another body, with the parts of which thoſe of one of the principles of the compound may contract an union, infinitely ſuperior to that which they had with the parts of the other principles of the compound. In this caſe, the principles of the compound muſt evidently be diſunited; one of theſe principles muſt form a new compound with the new ſubſtance applied to it, and the molecules of the other principles, being now diſengaged, muſt exerciſe their tendency upon each other, and form ſmall aggregates; which, when they have arrived at a certain maſs, muſt yield to the gravity by which they tend to the center of the earth. Thus we may conceive how *precipitations* are effected.

This will become clearer by an example; and for this purpoſe, let us chooſe a compound, ſuch as that which reſults from the union of nitrous acid with ſilver. From experience we know that when copper is applied to this compound, the nitrous acid quits the ſilver to combine with the copper, with which it forms a new compound; and that ſilver thus ſeparated from this acid, by the preſence and contact of the copper, has no longer any adherence with the acid, unites again into larger molecules, the maſs of which becomes ſo large, that they cannot yield to any other tendency than to the general gravitation which all bodies of a certain maſs have towards the center of the earth; and accordingly we ſee the molecules of ſilver fall to the bottom of the veſſel in which this operation is made. I ſay, firſt, that we cannot conceive what happens in this operation, unleſs we ſuppoſe that the force which unites the parts of the ſilver with thoſe of the nitrous acid evaniſhes, or becomes ineffectual, in compariſon of that force which tends to unite, and which does unite, theſe parts of the nitrous acid with the parts of the copper. In the ſecond place, ſuppoſing always that all chemical combinations and decompoſitions are the effects of a mutual and particular gravitation of the integrant and conſtituent parts of bodies to each other, which is in a ratio of the denſity and contact of theſe ſame parts; I ſay, that if in the preſent caſe, the parts of the nitrous acid quit the ſilver to unite with the copper, the integrant parts of this latter metal muſt have infinitely more denſity, or muſt be capable of having a much more extenſive and intimate contact with the parts of the nitrous acid than thoſe of the ſilver. Whence the action of the parts of the nitrous acid, which is only very imperfectly ſatisfied by their union with the parts of the ſilver, is in ſome meaſure exhauſted by the new union with the parts of the copper; ſo that only an infinitely ſmall force of adheſion to the parts of the ſilver remains; and then we may eaſily conceive that the tendency of the parts of the ſilver to each other may be more than is ſufficient to overcome this ſlight adheſion; and conſequently the parts of ſilver may really ſeparate from the nitrous acid, and may form ſenſible maſſes capable of yielding to the general gravitation to the center of the earth.

Hence alſo, if, at the ſame time that the parts of the nitrous acid are determined by the preſence and contact of the parts of the copper, to ſeparate from thoſe of the ſilver, theſe parts of ſilver ſhall find within their reach ſome other ſubſtances, with the parts of which they have a ſtill greater diſpoſition to unite than with each other, they will unite with this ſubſtance, and form a new compound; which circumſtance ought to facilitate the ſeparation of ſilver from the nitrous acid; and which alſo, when the ſilver has a ſtrong affinity with the matter preſented to it, might effect the ſame decompoſition, although even the copper had not a ſufficiently ſtrong affinity with the nitrous acid to ſeparate it from the ſilver. This ſeems actually to happen in the caſe of two new decompoſitions and combinations, which can only be performed by *double affinities*.

All the other phenomena which happen in chemical combinations and decompoſitions may be eaſily deduced from the ſuppoſitions we have made, and are only the neceſſary conſequences of theſe ſuppoſitions. For theſe phenomena, we refer to the articles AFFINITY, AGGREGATION, COMPOSITION, COMBINATION, DECOMPOSITION, SOLUTION, PRECIPITATION, *and* PRECIPITATES.

I am ſenſible that this intereſting matter is liable to great difficulties and objections, and is here but ſuperficially treated. Perhaps time, experience, the encreaſe of chemical knowledge, laſtly, the zeal of perſons ſkilled in mathematics and chemiſtry, will hereafter throw much more light upon theſe ſubjects, of which now we have but confuſed notions. However, I cannot but conſider them as the true key of the moſt hidden phenomena of chemiſtry, and conſequently of all natural philoſophy.

CCCLVI. GREAT WORK. The great work is the alchemical proceſs by which gold is made, or pretended to be made.

CCCLVII. GRITT-STONE. (s)

CCCLVIII. GUMS. Gums are mucilaginous juices which ſeparate ſpontaneouſly from ſeveral plants or trees, and which have acquired a ſolid conſiſtence by the evaporation of the greateſt part of their ſuperabundant water. Formerly all concrete juices collected from trees, whatever their nature was, were called gums. Hence many of theſe juices, which are entirely or partly reſinous, are ſtill called gums; ſuch are *gum copal*, *gum elemi*, *gum anime*, *gumma gutta*, and many others: but modern chemiſts and naturaliſts have with propriety conſidered only the concrete mucilages ſoluble in water as true and pure gums. We ſhall therefore treat of theſe gums only in this article.

Gums have a firm and ſolid conſiſtence, a certain degree of elaſticity, and great tenacity of their parts. Theſe latter properties render them capable of reſiſting percuſſion without being broken; by which they are rendered very difficultly pulveriſable in a mortar. They are more or leſs white and tranſparent: ſome of them, nevertheleſs, are of a yellow or brown color, but the matters by which they are colored are foreign to them. Very pure gums have no ſmell, ſcarcely any taſte, or a very mild and ſlight taſte. They are not ſoluble, either by oils, or by ſpirit of wine, but are perfectly ſoluble in water; and when the quantity of water uſed for this ſolution is but moderate, they form with it a thick, viſcid, tranſparent fluid, and they again become mucilages, ſuch as they were originally.

Although gums are obtained from many trees and plants of very different kinds, all gums, nevertheleſs, are very ſimilar, and do not properly differ from each other but by the quantity of mucilage which they are capable of forming with water. Three principal kinds of gums are diſtinguiſhed. Theſe are *gum tragacanth*, *gum arabic*, and *ordinary gums*.

Gum tragacanth iſſues from a thorny ſhrub called *tragacanth*, which grows in Syria and other oriental countries. It conſiſts of ſmall twiſted bits, the ſurfaces of which, when broken, are ſhining. It contains more mucilage, and is therefore dearer than any other gum.

Gum arabic is obtained from a kind of acacia, and perhaps from ſeveral other trees which grow in Arabia and in Africa. It conſiſts of round, rough pieces; ſome of which are beautiful, white, and tranſparent.

(s) GRITT-STONE is a ſtone conſiſting of particles of ſand agglutinated together. The differences of theſe ſtones proceed from the different ſizes of the particles of ſand compoſing them, the different properties of theſe ſands, and their different degrees of compactneſs and of agglutination. Some of theſe ſtones are employed for building, others for grinding, others for whetting ſharp ſteel inſtruments, and others for filtrating water.

Ordinary gums are thoſe which are gathered from moſt fruit-trees; ſuch as almond, apricot, plumb, and cherry trees, &c. It is generally leſs white and leſs tranſparent than gum arabic, though ſometimes it is as beautiful. Druggiſts pick the beſt pieces of theſe gums, and ſell them for gum arabic; from which no inconvenience proceeds, as they do not eſſentially differ from that gum.

As gum and mucilage are only one and the ſame ſubſtance united with a greater or leſs quantity of ſuperabundant water, theſe matters have abſolutely the ſame properties, and in their analyſis furniſh the ſame principles. For a further knowledge, therefore, of the nature of gums, we refer to the article Mucilage.

CCCLIX. GUM-RESINS. Gum-reſins are juices, partly mucilaginous and partly oily, which flow from many kinds of trees, and which become concrete by the evaporation of their fineſt fluid parts.

The oily and mucilaginous parts which form gum-reſins are intimately mixed, but not abſolutely combined with each other: hence theſe concrete ſubſtances are not perfectly ſoluble, either by water, by oils, or by ſpirit of wine, ſingly. When indeed any of theſe ſolvents, for example, water, is applied ſingly to moſt gum-reſins, and when the action of ſuch ſolvent is aſſiſted by trituration, a kind of ſolution is effected. The gummy part is entirely ſoluble in water, and forms a mucilage with it; while the reſinous part, which was originally much divided and intimately mixed with the gummy part, remains ſuſpended in the water, and conſequently forms a kind of milk or emulſion: but this oily part is then evidently divided only, but not diſſolved. *See* Emulsion. Thus the gum-reſin is reduced nearly to its original ſtate; I ſay, nearly, becauſe the oily ſubſtance loſes by drying its moſt fluid and volatile part, which is not reſtored to it by treating it with water in the manner above-mentioned.

We may alſo make a kind of ſolution of theſe gum-reſins, by employing ſolvents, which are partly watery, and partly oily or ſpirituous; ſuch as wine, vinegar, or aqua vitæ; but theſe ſolutions are always milky, from the water which hinders the ſpirituous part from combining intimately with the reſin. To diſſolve, therefore, completely a gum-reſin, the reſinous part muſt be ſeparated from the gummy part, by applying alternately a ſpirituous menſtruum, and a watery menſtruum.

From theſe properties of gum-reſins, relating to their ſolubility, chemiſts have diſcovered their true nature; for from moſt of their other properties, and particularly from their external appearance, they might be confounded with pure reſins, to which they have a ſtrong reſemblance. Here we ought to remark, that the proportion of the gum and of the reſin is not conſtantly the ſame in different gum-reſins, in ſome of which the gummy part is very ſmall in proportion to the reſinous: hence, upon a more particular examination of the concrete juices which iſſue from trees, many of them are claſſed among the gum-reſins, which formerly had been conſidered as pure reſins; and this ſubject is ſtill very uncertain. Nevertheleſs, as all gum-reſins are mixtures of ſubſtances which are not mutually ſoluble by each other; and as from ſuch a mixture the compound bodies which reſult muſt be opake; we may diſcover, merely by the view, whether any concrete juice be a gum-reſin or not. All thoſe which are opake, or are not evidently tranſparent, may reaſonably be ſuſpected to be of a gummy-reſinous, or extractive reſinous nature. Of this kind are *myrrh*, *bdellium*, *ſagapenum*, *opoponax*, *aſſa-fœtida*, and others which are evidently gum-reſins. On the contrary, all thoſe which are very tranſparent may be certainly conſidered either as pure gums or pure reſins: ſuch are the gums *tragacanth* and *arabic*; and the pure reſins *maſtic*, *ſandarac*, *gum-copal*, and other diaphanous ſubſtances, which may be diſcovered to be pure reſins, and diſtinguiſhed from pure gums, by their ſmell, inflammability, and other qualities peculiar to oily matters.

This rule, which certainly may be uſeful in determining without trouble concerning the nature of concrete juices, ought not to prevent us from making other ſuitable trials, and particularly thoſe by applying different menſtruums, when we would certainly determine the nature of the matter to be examined. Theſe trials are particularly neceſſary for thoſe concrete juices which are but little tranſparent, and are ſtrongly colored. Such are *gum-lac*, *gumma gutta*, *ſanguis draconis*, *aloes*, *opium*: for theſe latter concrete juices are ſtill more compounded than pure gum-reſins, and contain different coloring and extractive matters. *See* OILS, MUCILAGE, EXTRACTS, EMULSIONS, GUMS, *and* RESINS.

CCCLX. GUN-POWDER. *See* POWDER.

CCCLXI. GUYAC. Guyac is a very hard, heavy, compact wood of a tree which grows in hot countries, particularly in the Antilles Iſlands, and in other parts of America. It contains much reſin, which may be extracted from it by ſpirit of wine, in the ſame manner as the reſins of jalap, turpentine, &c. may be extracted from the vegetables which contain them. *See* ANALYSIS *by* MENSTRUUMS, *and* RESINS.

Guyac wood, when diſtilled with a heat not exceeding that of boiling water, is not, properly ſpeaking, decompoſed; ſince nothing paſſes over but a pure, or almoſt pure, phlegm, which ſeems to be nothing elſe than the ſuperabundant water it contains: a naked fire, therefore, is neceſſary for the decompoſition of this and all other woods. When guyac is to be diſtilled, it is to be cut into thin ſhavings, and put into a ſtone-ware retort; to which is to be adapted a large glaſs receiver with a ſmall hole pierced in its ſide; and the diſtillation is to be promoted by a graduated fire. At firſt, a liquor almoſt purely watery is obtained; and then, upon encreaſing the fire, an acid, reddiſh, empyreumatic liquor paſſes over, together with a little fluid reddiſh oil. Theſe reſults riſe in white vapors, and, at the ſame time, a conſiderable quantity of air is diſengaged, which would burſt the receiver, if it was not allowed to eſcape through the ſmall hole, which is ſometimes opened for that purpoſe. The acid and oil continue to riſe thus to the end of the diſtillation; the acid becoming ſtronger and ſtronger, and the oil becoming more and more empyreumatic, black, and thick; ſo that, at laſt, its conſiſtence is equal to that of turpentine. Laſtly, when the retort is thoroughly red-hot, the diſtillation is finiſhed. In the retort, the ſhavings of guyac are found reduced to perfect coal; but ſtill retain their original form. The acid, called alſo the *ſpirit*, and the oil are found together in the receiver, and may be ſeparated from each other by a funnel.

This analyſis of guyac is well known by chemiſts, becauſe the empyreumatic oil produced was one of the firſt which was obſerved to be capable of inflammation by mixture with ſpirit of nitre; and becauſe this analyſis is generally given as an example of the diſtillation of vegetables with a naked fire.

Thus, for inſtance, all the odoriferous plants from which the ſpiritus rector, eſſential oil, and other volatile principles, have been extracted by a degree of heat not exceeding that of boiling water, being afterwards diſtilled with a naked fire, without which they cannot be decompoſed, yield principles analogous to thoſe obtained from guyac wood.

The analyſis of guyac wood exhibits ſome phenomena deſerving attention. The great quantity of air diſengaged during this operation is very remarkable. It proves that this element is truly combined in certain bodies, and particularly in this; that is to ſay, that its integrant parts are diſunited from each other, and adhere to ſome of the united parts of the guyac. This is proved by the long time during which the air diſengages itſelf from the guyac; for this element being much more volatile than water, if it was not combined and retained by ſome fixed principle to which it is united, it would be ſoon diſengaged, and with a heat much leſs than that which is ſufficient to raiſe the ſuperabundant and uncombined water of the guyac. Beſides, this air ſeems to be deprived of its elaſticity while it remains in this compound; otherwiſe, it could not be condenſed into ſo ſmall a ſpace, but by a violent compreſſion. But this privation of the elaſticity of the air proves alſo that its aggregation is broken, in the ſame manner as the phlogiſton, or combined fire, has neither light, heat, nor fluidity, which are properties eſſential to it, when it is in its ſtate of aggregation.

The acid obtained in diſtillation with a naked fire from guyac and other ſimilar vegetables is ſtill united, and even intimately, with a conſiderable portion of oil. This appears from its color, and particularly from its empyreumatic ſmell; for this ſmell cannot be contracted by any thing but oil: beſides, the acid may be deprived of much of this empyreumatic oil, by further operations, and particularly by ſaturating it with alkalis, from which it may be afterwards ſeparated by a ſecond diſtillation. In both theſe operations much of the oil is ſeparated, and thus the acid is rectified.

This portion of empyreumatic oil is found to be well combined with the acid after the firſt diſtillation; for it no longer diſturbs its tranſparency, even when it is mixed with much water; becauſe the acid ſerves as an intermediate ſubſtance to keep the oil and water ſuſpended or diſſolved.

This rectification of empyreumatic vegetable acids has not been carried ſo far by chemiſts, as it might be.

The oil obtained in this diſtillation is acrid and empyreumatic, it being one of thoſe which are incapable of being diſtilled but by a heat much ſuperior to that of boiling water, by which heat all oils are much altered, acquire a burnt and empyreumatic ſmell, and allow much of their acid to eſcape. *See* Oil. The oil of guyac is employed, as all thoſe equally acrid, to facilitate the exfoliation of carious bones.

Laſtly, the coal found in the retort is a perfect coal, when the diſtillation has been continued till the retort has been red-hot; otherwiſe the reſiduum would contain ſome thick and half-burnt oil; but it is contrary to the nature of coal to contain any oil. *See* Coal.

CCCLXII. GUHR. (t)

(t) Guhr, *Creta fluida*, *Medulla fluida*, *Marga fluida*. Thoſe names are given to a liquid calcareous or chalky ſubſtance, white or aſh-colored, found generally in mines and

CCCLXIII. GYPSUM. Gypſum is a ſoft, friable, ſtony matter, which does not ſtrike fire with ſteel. It is found in large quantities in many parts of the earth, forming large mountains, and very extenſive chains of mountains and hills, as in the neighbourhood of Paris.

Gypſum is always cryſtallized, or regularly diſpoſed. In its cryſtallization it affects ſeveral different forms. The firſt form is that of large, tranſparent, ſhining, thin laminæ applied to each other, ſo exactly, that they conſtitute maſſes as tranſparent as cryſtal. Theſe are called by naturaliſts, *lapis ſpecularis*, from their large ſhining ſurfaces, like thoſe of mirrors.

In the ſecond place, a large quantity of gypſum is found cryſtallized in ſtriæ, like threads applied longitudinally to each other. This is called *ſtriated gypſum*. Laſtly, a very large quantity of gypſum is found in ſmall irregular cryſtals, agglutinated to each other, forming conſiderable maſſes of ſemi-tranſparent granulated ſtones, commonly called *gypſeous alabaſter*, when they are very white and pure, which gives them a more beautiful and perfect ſemi-tranſparency. *See* ALABASTER. (*u*)

All theſe gypſums, although very different in external appearance, are perfectly ſimilar as to their chemical and eſſential properties.

When expoſed to a very moderate heat, they quickly loſe their tranſparency, and acquire an opake white color. They alſo become very friable by expoſure to this heat, and the laminæ of the lapis ſpecularis ſeparate from each other.

Gypſum in this ſtate, mixed and kneaded with water, forms a kind of mortar, which ſoon hardens into a ſolid body. This property renders it very uſeful for buildings, in the conſtruction of which it is employed under the name of *plaſter*. And, in fact, nothing can be more convenient than a ſtone which in its ſoft ſtate is capable of receiving any form, which it afterwards preſerves many years by its property of hardening.

The properties above-mentioned are peculiar to gypſeous matters, and diſtinguiſh them from *talcs*, *amianthus*, *asbeſtus*, with which they frequently have an external reſemblance.

Gypſum by other properties reſembles calcareous earths. Thus, when it is calcined and put into water, a pellicle like the cream of lime is formed upon the ſurface of the water. This water makes the ſyrup of violets green, as lime-water does. Laſtly, gypſum acts a little upon ſulphur, and makes it a kind of earthy hepar of ſulphur, as quicklime does: but, nevertheleſs, gypſeous and calcareous ſtones ought not to be confounded together.

Gypſum differs from calcareous earth in this, that it does not diſſolve and effervеſce with acids. Mr. Pott obſerves, that vitriolic and nitrous acids being treated with gypſum, do not loſe their acidity; whereas theſe acids are eaſily

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ſubterranean places, where it drops and forms ſtalactitical concretions. There are alſo *metallic guhrs*, or liquid maſſes, ſometimes found in mines, containing metallic particles; and which, by dropping, form metallic ſtalactitical concretions.

(*u*) Beſides the gypſums above-mentioned, a rhomboidal gypſeous ſtone is found, called alſo *ſelenites*, ſometimes laminated, and ſometimes not. It is diſtinguiſhable from rhomboidal calcareous ſpars by the general properties of gypſeous earths, and by its truncated angles. Other gypſums are found, conſiſting of differently formed cryſtals, as hexagonal parallelipipedons and pyramids.

neutraliſed by calcareous earth, with which they form neutral ſalts with earthy baſes. Mr. Beaumé remarks, that gypſum may indeed be diſſolved in ſome meaſure by acids; but that the gypſum thus diſſolved is afterwards ſeparated by cryſtallization, and is in the ſame ſtate as it was before that ſolution, without retaining any part of the acids. Beſides, quicklime does not harden, as gypſum does, without addition of ſand or cement.

Theſe differences are ſufficient to diſtinguiſh gypſeous from calcareous earths. But this diſtinction is further eſtabliſhed by experiments which have been lately made by chemiſts to determine the nature of gypſum.

Mr. Pott, in his Lithogeognoſia, places gypſum amongſt the four principal kinds of earths, to which he refers all the others, and conſequently diſtinguiſhes it very accurately from the three other principal earths, and particularly from calcareous earth. He relates in that work many experiments made upon gypſum, to ſhew its nature and properties. Gypſum, according to him, cannot be fuſed without addition by the moſt violent fire of furnaces. Some chemiſts had affirmed that it was fuſible by the heat of ſolar rays collected by mirrors. Mr. Pott did not repeat that experiment.

I have expoſed lapis ſpecularis to the focus of a good burning mirror; and I remarked, that while the focus of rays fell upon its flat ſurface, the ſtone was only calcined, and not fuſed; but that when the focus was applied to the ſide of the ſtone formed by the edges of the plates or laminæ placed upon each other, this gypſum was immediately fuſed with a conſiderable ebullition. (x)

From Mr. Pott's experiments we chiefly learn, that gypſum or gypſeous alabaſter, (for that was the kind which he made the ſubject of his experiments) may be fuſed and vitrified when mixed with argillaceous earths, to which it ſerves as a flux, as calcareous earth does: but in this fuſion with argillaceous earth, gypſum bubbles and ſwells much more than pure calcareous earth does.

This fuſion of clay procured by gypſum, as by calcareous earth, as well as the other properties common to gypſum and calcareous earth, are occaſioned by the greateſt part of the gypſum being really compoſed of calcareous earth, which earth has been proved to be united in this compound with vitriolic acid. Mr. Macquer, in his Memoir upon Quicklime and Plaſter, printed amongſt the Memoirs of the Academy for the year 1747, mentions the vitriolic acid as one of the conſtituent parts of gypſum.

Mr. Pott, in his Lithogeognoſia, ſays, that ſeveral Authors rank amongſt gypſums a compoſition reſulting from the union of vitriolic acid with a calcareous earth; and that they call this compound *ſelenitic earth*, or *artificial gypſum*. Although Mr. Pott found ſome ſlight differences betwixt this compound and natural gypſum, yet the former had all the eſſential properties of the latter.

Mr. Macquer, treating of hard waters, in his Elements of Chemiſtry, ſays, that their hardneſs is occaſioned by a gypſeous ſelenites which is diſſolved in them. Laſtly, Mr. Margraaf ſays, that from gypſum diſtilled with powder of charcoal he obtained a volatile ſulphureous acid and true ſulphur; that having treated it with the alkali of tartar, by the dry and by the humid way, he obtained from it a vitriolated tartar; that the remaining earth was calcareous; that gypſum is entirely ſoluble in water; and that it may be artificially compoſed by ſaturating vitriolic acid with calcareous earth. *Opuſc. Chem.* 13 *Diſſ*

(x) From Mr. D'Arcet's Memoir upon the Effects of violent and long-continued Heat, we find that all gypſeous ſtones and earths are fuſible by the fire of furnaces. This, however, we may obſerve concerning the fuſibility of gypſum, that if it be expoſed long to a moderate fire not ſufficient to fuſe it, much of its vitriolic acid will be expelled, and part of it will be reduced to a calcareous earth, as unfuſible as chalk, or the other earths of that kind; therefore, a violent heat ſuddenly applied is neceſſary to the fuſion of gypſum.

We may then conſider, that gypſum has been demonſtrated to be nothing elſe than calcareous earth ſaturated with vitriolic acid. It is a vitriolic ſalt with baſis of calcareous earth; that is, it is a true *ſelenites.* *See* SELENITES

From this account we may explain all the properties of gypſum. Its want of hardneſs, its tranſparency, its cryſtallization, its ſolubility in water, proceed from its ſaline character. It cannot be combined with any acid, becauſe it is naturally ſaturated with the vitriolic acid. It requires much water to diſſolve it, which proceeds from its ſelenitic quality; that is, from the great quantity of earth which it contains, and the intimacy with which this earth is united with the vitriolic acid. Its calcination, by which the coheſion of its parts are deſtroyed, is nothing elſe than the ſubſtraction of the water of its cryſtallization. *See* CRYSTALLIZATION.

The properties of quicklime which gypſum acquires by calcination, ought alſo to be attributed either to the ſuperabundant calcareous earth which it may contain or rather to the ſubſtraction of a portion of the vitriolic acid, which is diſengaged during the calcination, chiefly by touching ſome inflammable matters, with which this acid unites and forms ſulphur. Laſtly, the hardening of plaſter, when calcined and mixed with water, may proceed from a mixture of thoſe parts, which by calcination have become quicklime, with thoſe other parts which have not acquired that quality, and which ſerve to the former as a cement, as Mr. Macquer conjectures in the above quoted memoir (*See* QUICKLIME): or elſe this hardening proceeds from the gypſum reſuming the water of its cryſtallization, and again cryſtallizing precipitately and confuſedly, as many chemiſts think, and particularly Mr. Pott, who ſays, "As plaſter mixed with water "does not harden, but when it is left at reſt, (for if it be ſtirred too long, it "will not become hard) we ought to conclude, that in this caſe a cryſtallization very ſuddenly happens, which conſequently ſuppoſes a very divided "ſaline ſubſtance, uniformly diffuſed through the plaſter, as Stahl has obſerved. "This alſo is the reaſon of the want of durability of plaſter in the air; becauſe "the air alters and attacks the ſaline ſubſtance which it contains."

Some chemiſts and naturaliſts have given to gypſum the name of *ſpar*, or rather diſtinguiſh a kind of ſpar by the appellation, *gypſeous*; becauſe this ſpar has the principal properties of gypſum. *See* SPAR.

H.

CCCLXIV. HARDNESS. Hardneſs is a quality of certain bodies which conſiſts in an intimate union and ſtrong adheſion of their integrant parts, which cannot therefore be eaſily disjoined.

We cannot preciſely determine what diſpoſition of parts occaſions the greateſt hardneſs: but this probably depends on the perfection and extent of the contact of theſe parts; and this quality depends eſſentially upon their figure, which we do not know.

The hardeſt bodies which we know are vitrifiable ſtones; and amongſt theſe, the hardeſt are thoſe which are the moſt pure and homogeneous; that is, diamonds.

Not any one of all known bodies is perfectly hard. Perfect hardneſs belongs undoubtedly to the primary, elementary, and conſtituent parts of matter, which of all beings we know the leaſt of.

CCCLXV. HELLEBORE. (y)

CCCLXVI. HEMATITES. (z)

(y) **Hellebore.** Two ounces of the root of *white hellebore* yielded, with water, nine drams and a ſcruple of gummy extract; and the ſame quantity of root yielded with ſpirit of wine ſeven drams of reſinous extract. From ſix ounces of the root of *black hellebore*, ſix drams and a ſcruple were extracted by ſpirit; and from the ſame quantity of root ſix drams and two grains were extracted by water. Borrichius relates, that the diſtilled water of the whole plant poſſeſſes emetic and purgative qualities.

(z) **Hematites**, or *Bloodſtone*, is a hard mineral ſubſtance, red, black, or purple; but the powder of which is always red; ſometimes of an intermediate figure, and ſometimes ſpherical, ſemi-ſpherical, pyramidal, or cellular, that is, like a honey-comb; conſiſting of pyramids generally ſmall, the apices of which appear, in a tranſverſe ſection, in the center. It contains a large portion of iron. Forty pounds of this metal have been extracted from a quintal of the ſtone. But the iron is obtained with ſuch difficulty, and is of ſo bad a quality, that this ore is not commonly ſmelted. The great hardneſs of hematites renders it fit for burniſhing and poliſhing metals.

CCCLXVII. **HEPAR.** (a)

CCCLXVIII. **HETEROGENEOUS,** *and* **HOMOGENEOUS.** Heterogeneous ſignifies of different natures; and homogeneous ſignifies of the ſame nature.

CCCLXIX. **HOPS.** (b)

CCCLXX. **HYDROMEL.** Hydromel is honey diluted in nearly an equal weight of water. When this liquor has not fermented, it is called *ſimple hydromel*; and when it has undergone the ſpirituous fermentation, it is called the *vinous hydromel*, or *mead*.

Honey, like all ſaccharine ſubſtances, vegetable or animal, is ſuſceptible of fermentation in general, and particularly of the ſpirituous fermentation. To induce this fermentation, nothing is neceſſary but to dilute it ſufficiently in water, and to leave this liquor expoſed to a convenient degree of heat. To make good vinous hydromel, or mead, the whiteſt, pureſt, and beſt-taſted honey muſt be choſen, and this muſt be put into a kettle with more than its weight of water; a part of this liquor muſt be evaporated by boiling, and the liquor ſcummed, till its conſiſtence is ſuch, that a freſh egg ſhall be ſupported upon its ſurface without ſinking more than half its thickneſs into the liquor; then the liquor is to be ſtrained, and poured through a funnel into a barrel: this barrel, which ought to be nearly full, muſt be expoſed to a heat as equable as is poſſible, from 20 to 27 or 28 degrees of Mr. Reaumur's thermometer, taking care that the bung-hole be ſlightly covered but not cloſed. The phenomena of the ſpirituous fermentation will appear in this liquor, and will ſubſiſt during two or three months, according to the degree of heat; after which they will diminiſh and ceaſe. During this fermentation, the barrel muſt be filled up occaſionally with more of the ſame kind of liquor of honey, ſome of which ought to be kept apart on purpoſe to replace the liquor which flows out of the barrel in froth. When the fermentation ceaſes, and the liquor has become very vinous, the barrel is then to be put in a cellar and well cloſed. A year afterwards the mead will be fit to be put into bottles.

The vinous hydromel or mead is an agreeable kind of wine; nevertheleſs it retains long a taſte of honey, which is unpleaſing to ſome perſons; but this taſte it is ſaid to loſe entirely by being kept a very long time.

The ſpirituous fermentation of honey, as alſo that of ſugar, and of the muſt of vinous liquors, when it is very ſaccharine, is generally more difficultly effected, requires more heat, continues longer, than that of ordinary wines made from the juice of grapes; and theſe vinous liquors always preſerve a ſaccharine taſte, which ſhews that a part only of them is become ſpirituous. The cauſe of this probably is, that they contain leſs acid, or that they contain an acid leſs diſengaged than the muſt of ordinary wine. *See* FERMENTATION *and* WINE.

(a) HEPAR. *See* LIVER.

(b) HOPS are uſually added to malt liquors, and are ſaid to render theſe liquors leſs apt to become ſour, leſs viſcid, and more wholeſome by their aromatic bitterneſs. They contain a ſubtle odorous principle, which promotes the vinous fermentation. When infuſed, or but ſlightly boiled in wort, they encreaſe its ſpirituoſity. *Neuman.*

CCCLXXI. HONEY. Honey is a ſaccharine fermentable juice collected by bees from flowers. *For the nature and properties of honey ſee* SUGAR.

CCCLXXII. HORN *of* ANIMALS. The horn of animals is of the ſame nature as their gelatinous matter, and is only that matter charged with a leſs quantity of water, with a larger quantity of earth, and ſufficiently condenſed to have a firm and ſolid conſiſtence. By digeſting horn with water in Papin's digeſter, it may be entirely converted into jelly.

Horn is a perfectly animaliſed matter, and furniſhes in diſtillation the ſame principles as all animal matters; that is, at firſt a pure phlegm, with a degree of heat not exceeding that of boiling water; then a volatile alkaline ſpirit, which becomes more and more penetrating and ſtrong; a fetid, light, and thin oil; a concrete volatile ſalt, which forms ramifications upon the ſides of the receiver; much air; fetid oil, which becomes more and more black and thick; and laſtly, it leaves in the retort a conſiderable quantity of almoſt incombuſtible coal, from which, after its incineration, ſcarcely any fixed alkali can be obtained.

Animal oil, and particularly that which is drawn firſt in the diſtillation of horn, is ſuſceptible of acquiring great thinneſs and volatility by repeated diſtillations, and is then called *the oil of Dippel*. *See that article.*

The horns of ſtags, and of other animals of that kind, are the moſt proper to furniſh the animal oil to be rectified in the manner of Dippel; becauſe they yield the largeſt quantity. Theſe horns alſo differ from the horns of other animals in this, that they contain a larger quantity of the ſame kind of earth which is in bones; hence they ſeem to poſſeſs an intermediate nature betwixt horns and bones.

CCCLXXIII. HORN (HART'S) CALCINED *to* WHITENESS. The phlogiſton of the coal of hart's-horn, although very difficultly combuſtible, may nevertheleſs be burnt with more eaſe than the coal of other horns, and with nearly the ſame facility as bones may. This coal, by being calcined with a long-continued and ſtrong fire, is changed into a very white earth called hart's horn calcined to whiteneſs. This earth is employed in medicine as an abſorbent. It is given in dyſenteries and labor-pains which are ſuppoſed to be cauſed by acrid and ill-digeſted matters. Hart's-horn calcined to whiteneſs and levigated is the baſis of Sydenham's *white decoction*, which is commonly preſcribed in theſe diſeaſes.

CCCLXXIV. HORN (HART'S) PREPARED PHILOSOPHICALLY. This name is given to hart's-horn deprived by water of almoſt all its gelatinous part; ſo that it becomes brittle; and when its outer part is taken off, it is thus rendered very white, and is applicable to the ſame uſes as that which is calcined by fire.

CCCLXXV. HORN-BLEND. (*c*)

(*c*) HORN-BLEND is a black or green indurated bole or clay, conſiſting of ſcaly particles, which are diſtinguiſhable from thoſe of mica, by being leſs ſhining, thicker, and rectangular. It is generally found amongſt iron ores, and ſometimes intermixed with mica, forming a compact ſtone.

CCCLXXVI. HORNSTEIN. (d)

CCCLXXVII. HYACINTH. (e)

(d) HORNSTEIN, *Petroſilex Wallerii.* This name is given by German authors to the ſiliceous ſtone called in England chertz. *See* CHERTZ.

(e) HYACINTH, or JACINTH, is a precious ſtone, polygonal, more or leſs tranſparent, of a yellowiſh red-color, the ninth in degree of hardneſs from diamonds, and fuſible by fire.

I.

CCCLXXVIII. **JACINTH.** *See* **HYACINTH.**

CCCLXXIX. **JALAP.** (*f*).

CCCLXXX. **JAPONIC EARTHS.** (*g*).

CCCLXXXI. **JASPER.** (*h*).

CCCLXXXII. **ICHTHYOCOLLA.** *See* **ISINGLASS.**

CCCLXXXIII. **JELLY.** From many vegetables, mucous ſubſtances capable of forming kinds of jelly are obtained, but theſe are more frequently called *mucilages* and *gums*. The name *jelly* or *gelatinous matter* is particularly applicable to the mucous ſubſtance obtained from animals.

The bodies of moſt animals ſeem to be chiefly compoſed of gelatinous matter. For if we boil in water, fleſh, bones, membranes, tendons, nerves, horns, ſkin, in a word, any of the ſeveral ſolid or ſoft parts which compoſe animal bodies, and if we evaporate ſufficiently this water, the liquor by cooling will become a true jelly. If the evaporation be continued till the matter be dry, but with a heat incapable of decompoſing this jelly, it forms at firſt a glue, and afterwards a horny ſubſtance more or leſs tranſparent, hard and ſolid.

(*f*) Jalap. From ſixteen ounces of root of jalap, ſpirit of wine extracted five ounces, and four ſcruples of reſinous matter; and from the reſiduum, water extracted two ounces and a half of gummy-matter. This root is obſerved to have a conſiderable power in promoting the ſpirituous fermentation of ſweet vegetable juices, as of melaſſes. *Newman*.

(*g*) Japan-earth. This name is improperly given to a gum-reſin, obtained by inſpiſſating the juice or decoction of the fruit of a certain palm-tree, which grows in the Eaſt Indies. It is almoſt entirely ſoluble, when pure, by water, or by ſpirit of wine. Its taſte is at firſt bitteriſh and ſtyptic, and is afterwards agreeably ſweet. *Newman*. The Indians are ſaid to cut the fruit of this tree into ſmall pieces, which they wrap in the leaves of the maritime plant *betel*, together with ſome quicklime, and to chew theſe balls, the taſte and ſmell of which they find to be very agreeable.

(*h*) Jasper is an opake ſiliceous ſtone, of various colors, white, green, red, yellow, black, or variegated with ſpots or with veins of different colors. It differs from flints and chertz in being opake, in being more eaſily fuſible by fire, in having a granulated texture, and in frequently compoſing large maſſes, or rocks; whereas flints and chertz are generally in form of nodules or lumps. From ſome jaſpers, iron may be obtained. They are ſufficiently hard and compact to receive and retain a fine poliſh.

When jaſpers are ſpotted with ſpecks of onyxes or agates, they are called *jaſponyxes*.

The blood, lymph, and ſeminal fluid of animals are ſcarcely any thing but pure gelatinous matter. Milk contains a large quantity of it. *See* Cheese. In a word, almoſt all animal liquors, excepting the excrementitious, ſuch as urine and ſweat, are nothing but kinds of watery jellies.

Hence we ought to conclude, that the gelatinous matter of animals is the true animal ſubſtance. It conſtitutes almoſt entirely the body of animals; it is that which nouriſhes, repairs, and reproduces them; it is in the animal kingdom, what mucilage is in the vegetable kingdom, from which it ſeems to be derived, and which it reſembles in many of its properties. *See* Gums *and* Mucilages.

This matter in its natural ſtate has ſcarcely any ſmell, or any acid or alkaline quality. Its taſte is ſweet and faint. When diluted with water, and by the help of other circumſtances neceſſary to fermentation, it eaſily ferments as ſoon as it is deprived of vital motion, and ſometimes even during the life of the animal to which it belongs. It occaſions ſeveral diſeaſes, and conſiderably deranges the animal economy. At firſt it tends ſlightly to the acid fermentation, as may be obſerved in milk, in blood, in fleſh, and broths; and then it paſſes very quickly to a compleat putrefaction, which reduces it to a very fetid liquid ſubſtance. *See* Fermentation and Putrefaction.

When it is very freſh, and expoſed to a degree of heat not exceeding that of boiling water, nothing riſes from it but its ſuperabundant phlegm, or water. By loſing this ſuperabundant water it becomes more and more gluey, and at length acquires nearly the conſiſtence of horn. In this ſtate, when it has ſuffered no other alteration than this kind of drying, it may be again diſſolved in water, and reſume its former liquid gelatinous ſtate.

Nevertheleſs, ſome gelatinous matters, ſuch as the whites of eggs, and the white part of the blood which is not watery, are coagulated and hardened by heat; and theſe, when once well dried, cannot be again rediſſolved in water, or at leaſt without great difficulty and particular management.

Acids and alkalis, the latter particularly, attack and diſſolve jelly, with great eaſe. The reſults of theſe combinations have not yet been ſufficiently examined.

Oily ſubſtances appear to have no action upon gelatinous matter. Neither can rectified ſpirit of wine diſſolve it. This ſpirit does not act upon it when it is dry, and only takes from it part of its water when it is [illegible] and thus coagulates it. It then appears a precipitate compoſed of little white flocks. To this property which ſpirit of wine has of coagulating jelly, is with much probability attributed, the thickening [illegible] the ſtuffing and breaking of the lymphatic veſſels, whence extravaſation and dropſy follow; in [illegible] the principal diſeaſes of thoſe who drink too much of ſpirituous liquors.

When dry gelatinous matter is expoſed to a degree of heat ſuperior to that of boiling water, it ſwells, riſes into bubbles, emits an acrid, empyreumatic, fetid ume, and is with difficulty, and not without a very violent heat, inflammable.

If it be diſtilled in a retort with a graduated [illegible] firſt a little phlegm is obtained; then [illegible] volatile alkali, a thin [illegible] penetrating oil, ſolid volatile alkali, and a [illegible] empyreumatic oil, which becomes more and more thick, follow in the or[illegible] are here ment[illegible] In the retort a conſiderable quantity of that [illegible] of coal remains, which cannot be burnt without great difficulty. From the aſhes of this coal an exceeding ſmall quantity of fixed alkali, and a little common ſalt may generally be obtained. Theſe are exactly the ſame ſubſtances which may be obtained from all animal matters. As many things are common to jelly and to vegetable mucilage, *ſee the word* MUCILAGE.

CCCLXXXIV. JET.* (i).

CCCLXXXV. INDIGO. (k).

CCCLXXXVI. INFLAMMATION *of* OILS *by* NITROUS ACID. The vivid inflammation occaſioned by mixing highly concentrated nitrous acid with moſt oils, is one of thoſe ſurprizing phenomena, which excite the admiration even of people the moſt unintelligent, and leaſt converſant in matters of chemiſtry and experimental philoſophy. No wonder, therefore, that it has particularly excited the attention of chemiſts. Glauber, Borrichius, Tournefort, Homberg, Rouviere, Dippel, Hoffman, Geoffroy, and Mr. Rouelle, have particularly applied themſelves to this matter. Theſe chemiſts have ſucceſſively found methods of inflaming different oils, and have publiſhed their proceſſes in their writings.

Borrichius, a Daniſh chemiſt, had affirmed in the Copenhagen Tranſactions for the Year 1671, that oil of turpentine may be inflamed by mixing it with nitrous acid. But as in that time a highly concentrated nitrous acid was very rare, moſt of the chemiſts who attempted to repeat this experiment, did not ſucceed. Tournefort, in the year 1700, inflamed by this method the oil of ſaſſafras. Homberg in the year 1701 ſays, in the Memoirs of the Academy, that he inflamed oil of turpentine by mixing it with nitrous acid; but he ſays that the oil muſt be thick. Rouviere, in the year 1706, inflamed the empyreumatic oil of guyac; and his experiment was much talked of, becauſe it ſucceeded more eaſily than the others, becauſe this inflammation is very vivid, and becauſe it is attended by a ſurprizing circumſtance; namely, that from amidſt the flames ariſes a black, thin, ſpongy body, of a conſiderable height, which is, as we ſhall ſee, only the thickeſt part of the oil rarefied and burnt during the inflammation. This inflammation of oil of guyac was ſolely attended to, and was ſhewn to ſtudents in courſes of chemiſtry and experimental philoſophy; till Hoffman, a German chemiſt, and Geoffroy, a French chemiſt, having made many experiments on this matter, diſcovered at the ſame time, that ſmoking nitrous acid mixed with concentrated vitriolic acid, ſucceeded infinitely better for the inflammation of oils, and particularly of the oil of turpentine, which had been almoſt relinquiſhed. Mr. Rouelle then reſumed this ſubject, and publiſhed in the year 1747, a Memoir filled with many experiments, which ſhewed, that by nitrous acid may be inflamed all eſſential oils, including oil of turpentine, and even thoſe ſweet expreſſed oils which are capable of quickly thickening and drying, ſuch as oils of nuts, linſeed, hemp, provided that the acid be ſufficiently concentrated. Laſtly, the ſame chemiſt diſcovered that even the ſweet oils leaſt diſpoſed to dry, that is, thoſe called *fat oils*, may alſo be inflamed. But to make their inflammation ſucceed, the method mentioned by Hoffman and Geoffroy was neceſſary; that is to ſay, ſome concentrated vitriolic acid muſt be previouſly mixed with the nitrous acid. As theſe laſt mentioned oils are of all oils the leaſt inflammable, we have reaſon to believe that every oil may be inflamed by a mixture of theſe two acids.

(i) JET, *Gagates, Succinum nigrum*, is a black bitumen, reſembling fine black ebony wood, hard, light, compact, and ſmooth. It is very inflammable, and burns with a bituminous ſmell. By diſtillation it yields, 1. an acid liquor; 2. a thin black oil; 3. a thick black oil. By friction it becomes electrical, as amber does. *See* BITUMEN.

(k) INDIGO is a blue fecula, obtained from the American plant *anil* by means of fermentation, in the following manner. The herb is put into a vat and covered with water. In a few hours the liquor begins to ferment, becomes hot, throws up a froth, and acquires a blue or violet color. The liquor is then emptied into another vat by means of a cock inſerted near the bottom of the firſt vat. In the ſecond vat, the liquor is to be continually and ſtrongly agitated by ſticks and buckets annexed to ſticks, by which means the blue coloring matter is made to unite together, or is diſpoſed to ſeparate from the liquor, and to ſubſide. When the blue matter has ſubſided, the water is let off by cocks, and the ſediment, when drained and dried in the air, is indigo.

Indigo may be almoſt entirely conſumed by fire. With water it may be formed into a paſte, diffuſible through more water; but at laſt the coloring matter ſubſides. By means of fixed alkaline ſalt it becomes permanently diffuſible in water. Woolen ſtuffs previouſly ſteeped in warm water, being dipped in the above liquor, are dyed of a green color, which is almoſt inſtantly, by expoſure to air, changed to a fine blue. Volatile alkaline ſpirits extract yellowiſh or browniſh red tinctures, and ſpirit of wine a reddiſh tincture; by digeſtion with indigo. Indigo gives no color to lime-water, or to water acidulated with vitriolic, nitrous, or marine acids. The concentrated vitriolic acid unites with indigo into a ſmooth paſte, eſpecially if the indigo be previouſly ground with powdered glaſs, or ſand. By this method, the indigo is rendered ſoluble in boiling water along with the acid, ſo as to paſs through a filter. This ſolution, when hot, is of a bright green color, and, when cold, becomes brown. The above experiments are mentioned by Dr. Lewis in a note to his tranſlation of Neuman's Works.

Mr. Rouelle further remarks, in the above quoted Memoir, that flame is more certainly produced in all theſe experiments, when the nitrous acid is poured on at intervals, and when it is applied to that part of the oil which the portions of acid firſt poured on had thickened, heated, and dried. The inflammation of oils by acids is now become an experiment eaſily performed. The following circumſtances are remarked to be peculiar to the inflammation of the ſeveral kinds of oil.

All eſſential oils, and even the ſweet drying oils, may be inflamed by the nitrous acid alone, provided that the veſſel in which the inflammation is to be made be of a convenient ſize and form, that the nitrous acid be ſufficiently concentrated, and that a ſufficient quantity of acid and oil be employed. The veſſel ought to be ſufficiently wide-mouthed; and the nitrous acid, for greater certainty, ought to be ſo concentrated that a phial capable of containing exactly an ounce of pure water, ſhall be capable of containing one ounce four gros and two ſcruples of this acid. Laſtly, an ounce of this acid, and as much of the oil to be inflamed, ought to be employed, although leſs quantities may ſucceed, but leſs certainly. The oil is firſt put into the veſſel in which the inflammation is intended to be. Then the veſſel containing the nitrous acid is to be tied to one end of a rod, that the operator may not be hurt by the part of the mixture which is generally thrown out of the veſſel, and ſometimes at a conſiderable diſtance. One half or two-thirds of the acid is poured at once. A conſiderable ebullition is excited by the reaction of theſe two liquors: The oil becomes black, thick, and ſometimes inflames. If it does not inflame within four or five ſeconds, more nitrous acid muſt be poured upon the part which appears thickeſt and dryeſt, and then the mixture never fails to be inflamed.

The oils of almonds, olives, rapes, and other fat oils, have not been hitherto inflamed by the nitrous acid alone. But their inflammation is effected, as Mr. Rouelle practiſes, by mixing with them firſt equal quantities of the concentrated vitriolic and nitrous acids, which occaſion leſs quick and violent ebullition than in the preceding inſtances; but when this ebullition is at its height, ſome pure nitrous acid muſt be poured on the thickeſt part of the mixture. Then the inflammation generally happens, but is leſs ſtrong than when any other kind of oil is uſed.

Although theſe phenomena be ſurprizing, their theory is eaſy. All oils contain phlogiſton as a conſtituent part. Nitrous acid alſo contains phlogiſton. Hence we may underſtand the cauſe of the powerful action of theſe two ſubſtances upon each other. The heat reſulting from their reaction, is equal to that of ignition; and hence the oil and even the nitrous acid being capable of inflammation, muſt conſequently be inflamed.

The reaction becomes more ſtrong, and the inflammation more certain, when the nitrous acid is applied to the part of the oil which has already been thickened and dried, either by the nitrous acid alone, or by that acid mixed with vitriolic acid. But ought this portion of thickened and dephlegmated oil to be conſidered as a pure coal? And ought the action of the diſengaged nitrous acid upon this thickened oil, to be compared to the action of nitre detonating with coal? We cannot be eaſily perſuaded of this, when we conſider that nitrous acid, however much concentrated, when not retained by ſome baſe, has no action upon any kind of coal, even when heated as much as poſſible. *See* DETONATION *of* NITRE.

The effect produced by the addition of the vitriolic acid, may be explained in the following manner. This acid does much promote theſe inflammations; ſince, on the one hand, it makes them ſucceed more certainly, and with leſs doſes than can be done with the nitrous acid alone; and on the other hand, ſome oils have never hitherto been made capable of inflammation without it. But although this acid acts powerfully upon oils, it cannot ſingly inflame any of them. Mr. Rouelle conſidering, that as the vitriolic acid is eſſentially ſtronger, and has a greater affinity to water than nitrous acid, believes that it renders the nitrous acid more capable of inflaming oils by dephlegmating it. Probably the vitriolic acid may from this cauſe facilitate the inflammation of oils; but has it not alſo as great an affinity with the water contained in the oils, as with that contained in the nitrous acid? and may not, conſequently, its power of facilitating theſe inflammations proceed from the dephlegmation of the oils, as well as of the nitrous acid?

CCCLXXXVII. INFUSION. Infuſion, taken in its moſt general ſenſe, conſiſts in placing compound bodies in a liquor intended to be impregnated with ſome of their principles, either without heat, or with a heat leſs than that of the boiling liquor.

From this definition we may ſee that infuſion is one of the principal operations of the analyſis by menſtruums, in the ſame manner as decoction is, of which infuſion may be conſidered as the firſt degree.

Infuſion may be made in watery, ſpirituous, oily, acid, or alkaline liquors, according to the nature of the matters to be infuſed, and of the principles intended to be extracted. It is nevertheleſs practiſed upon vegetable matters only, and almoſt always for the preparation of remedies which are alſo called *infuſions*.

Aromatic plants and other odoriferous vegetable matters are generally infuſed when their odoriferous principle is to be preſerved, in which their virtue conſiſts; and which is at the ſame time ſo volatile as to be diſſipated and loſt by the heat of ebullition. To preſerve ſtill better theſe volatile principles, the ſmalleſt heat requiſite for the extraction ought to be employed; and theſe infuſions ought to be made in matraſſes or other veſſels, which may be exactly cloſed.

The principles extracted by infuſion are different according to the menſtruum employed.

Pure water may be impregnated with the odoriferous principle, or ſpiritus rector, with ſaline, ſaponaceous, mucilaginous, extractive principles. Spirit of wine diſſolves the ſpiritus rector, the eſſential oils, thoſe reſinous matters the baſe of which is an oil of the nature of eſſential oils, and greateſt part of the ſaponaceous extractive matter. Thoſe infuſions made by ſpirit of wine are particularly called *tinctures*, eſpecially in pharmacy. Oils diſſolve the ſpiritus rector, and any oily matter. Acids and alkalis diſſolve the earthy ſubſtances of vegetables, and almoſt all their other principles: but they diſguiſe them, alter them, and change conſiderably their virtues by the combination. They are therefore not much uſed for theſe kinds of extractions. *See* ANALYSIS, DECOCTION, EXTRACTS.

CCCLXXXVIII. INK. Ink is a liquor, generally black, uſed for writing. Nevertheleſs ſome inks are of other colors.

The baſis of black ink is an infuſion of galls, and of martial vitriol, known to druggiſts by the name of green copperas; both which are mixed together, and to them is added ſome gum-arabic. The following receipt makes good ink: In four pints of common water or beer let a pound of bruiſed galls be infuſed twenty-four hours without boiling; to this add ſix ounces of gum-arabic; and when the gum is diſſolved, ſix ounces of green vitriol, which will ſoon give it the black color: the liquor is then to be ſtrained through a hair ſieve.

Galls and all vegetable aſtringents have the property of ſeparating iron, when it is united, either with vitriolic acid, or with any other acid; and the precipitate thus formed is black. The blackneſs of theſe precipitates is cauſed by a certain quantity of oily matter which they receive from the vegetable ſubſtances.

In the operation of making ink, ſomething paſſes analogous to the precipitation of iron into Pruſſian blue, by means of a phlogiſticated alkali. Some chemiſts having even remarked that ink diluted with much water has a color approaching to blue, have conſidered the martial precipitate of ink as a Pruſſian blue, the color of which is ſo intenſe as to ſeem black when diluted in a ſmall quantity of water; becauſe a very deep blue has actually the appearance of a black: but this opinion does not correſpond with the properties of ink or of Pruſſian blue. Iron precipitated in theſe two methods is eſſentially different; and the difference proceeds from the different natures of the two inflammable matters with which the iron unites itſelf in theſe two caſes. The inflammable matter which unites with iron in the preparation of ink is in an oily ſtate; and that in the preparation of Pruſſian blue is not in that ſtate. *See* Blue (Prussian). Accordingly the precipitate of iron in ink is eaſily ſoluble by all acids; but the precipitate of Pruſſian blue is not. If a ſufficient quantity of ſpirit of nitre, or any other ſtrong acid, be mixed with ink, its color will diſappear, and the blackeſt ink will thus be rendered clear and tranſparent as water. Its blackneſs and opacity may be again reſtored to it by adding to the ink thus diſcolored a ſufficient quantity of alkali to ſaturate all the acid which had diſſolved the martial precipitate; by which means this precipitate reſumes its former appearance. Thus the black color of ink may be made to diſappear and appear again as often as we pleaſe, by mixing with it alternately ſome acid and ſome alkali: but this change of color cannot be produced upon the Pruſſian blue. By adding any quantity of an acid to the water in which Pruſſian blue is ſuſpended, its color, ſo far from being altered, becomes only the more beautiful by that addition.

The color of Pruſſian blue may be indeed made to appear and diſappear at pleaſure by one method: but this method is preciſely the reverſe of that uſed to produce thoſe effects upon ink. By mixing much alkali with Pruſſian blue, its color is deſtroyed; and by ſaturating this alkali with an acid, the color is reſtored. This conſtitutes a very ſenſible difference betwixt theſe two martial precipitates.

Inks of all colors may be made by uſing a ſtrong decoction of the ingredients uſed for dying, mixed with a little alum and gum-arabic. For example, a ſtrong decoction of braſil wood with as much alum as it can diſſolve, and a little gum-arabic to give it body and ſome conſiſtence, forms a beautiful red ink. (*l*)

(*l*) As the duration of records and other valuable writings depends much on the goodneſs of the ink employed, Dr. Lewis has thought this ſubject worthy of his attention. The chief imperfection of common inks is, that they decay in time, and at laſt the writing becomes inviſible. From experiments made by that author, he infers that the decay of inks is chiefly owing to a deficiency of galls; that the galls are the moſt periſhable ingredient, the quantity of theſe, which gives the greateſt blackneſs at firſt, (which is about equal parts with the vitriol) being inſufficient to maintain the color; that for a durable ink, the quantity of galls cannot be much leſs than three times that of the vitriol; that it cannot be much greater without leſſening the blackneſs of the ink; that by diminiſhing the quantity of water, the ink was rendered blacker and more durable; that diſtilled water, rain water, and hard ſpring water, had the ſame effects; that white wine produced a deeper black color than water; that the color produced by vinegar was deeper than that by wine; that proof ſpirit extracted only a reddiſh-brown tinge; that the laſt mentioned tincture ſunk into, and ſpread upon, the paper; and hence the impropriety of adding ſpirit of wine to ink, as is frequently directed, to prevent mouldineſs or freezing; that other aſtringents, as oak bark, biſtort, ſloe-bark, &c. were not ſo effectual as galls, nor gave ſo good a black, the color produced by moſt of theſe, excepting oak-bark, being greeniſh; that the juice of ſloes did not produce a black color with martial vitriol; but that, nevertheleſs, the writing made with it became black, and was found to be more durable than common ink; that inks made with ſaturated ſolutions of iron in nitrous, marine, acetous, acids, in tartar, or in lemon juice, were much inferior to the ink made with martial vitriol; that the color of ink was depraved by adding quicklime, which was done with an intention of deſtroying any ſuperabundant acid which might be ſuppoſed to be the cauſe of the loſs of the color of ink; that the beſt method of preventing the effects of this ſuperabundant acid is probably by adding pieces of iron to engage it;

CCCLXXXIX. INKS (SYMPATHETIC). Chemiſtry furniſhes many methods of making the inks called ſympathetic. Theſe inks are colorleſs liquors, with which an inviſible writing is made, but which becomes very ſenſible when we pleaſe, by certain treatment appropriated to the particular kind of ſympathetic ink employed.

As ordinary ink is made black by a mixture of two liquors which are not, or but very little colored, it may become a ſympathetic ink by ſeveral methods.

If green vitriol be diſſolved in water, and a little acid be added, to prevent the yellowiſh martial precipitate, which is always formed when there is not ſuperabundant acid, with this ſolution inviſible characters may be written, which may be rendered very black, by being moiſtened with a ſtrong infuſion of galls.

If the blackneſs of ordinary ink be deſtroyed by a ſufficient quantity of nitrous acid, the writing made by it will remain inviſible, till it be moiſtened by liquid fixed alkali.

Characters traced with the acid ſolution of green vitriol above-mentioned will become of a fine blue color, if they be moiſtened with the phlogiſticated alkaline liquor uſed in the preparation of Pruſſian blue; and characters traced with this laſt mentioned liquor, which are abſolutely inviſible, may be rendered of a fine blue color by being moiſtened with a ſolution of green vitriol. The theory of theſe inks may be ſeen under the articles INK, *and* BLUE (PRUSSIAN).

Pure vitriolic acid, weakened by ſo much water that it ſhall not make too ſtrong an impreſſion upon paper, becomes a ſympathetic ink, the characters written with which are inviſible; but may be rendered ſenſible by heating the paper on which they are traced. This effect is occaſioned by the heat concentrating the acid, and rendering it capable of burning and blackening the paper. But

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and that this conjecture was confirmed by an inſtance the author had heard, of the great durability of the color of an ink in which pieces of iron had been long immerſed; and laſtly, that a decoction of logwood uſed inſtead of water, ſenſibly improved both the beauty and deepneſs of the black, without diſpoſing it to fade. The ſame author obſerves, that the addition of gum-arabic is not only uſeful, by keeping the coloring matter ſuſpended in the fluid, but alſo by preventing the ink from ſpreading, by which means a greater quantity of it is collected on each ſtroke of the pen. Sugar, which is ſometimes added to inks, was found to be much leſs effectual than gums, and to have the inconvenience of preventing the drying of the ink. The color of ink is found to be greatly injured, by keeping the ink in veſſels made of copper, or of lead, and probably of any other metal, excepting iron, which the vitriolic acid can diſſolve. The foregoing experiments point out for the beſt proportions of the ingredients for ink; one part of green vitriol, one part of powdered logwood, and three parts of powdered galls. The beſt menſtruum appears to be vinegar or white wine, tho', for common uſe, water is ſufficient. If the ink be required to be of a full color, a quart, or, at moſt, three pints, of liquor may be allowed to three ounces of galls, and to one ounce of each of the other two ingredients. Half an ounce of gum may be added to each pint of the liquor. The ingredients may be all put together at once in a convenient veſſel, and well ſhaken four or five times each day. In ten or twelve days the ink will be fit for uſe, though it will improve by remaining longer on the ingredients: or it may be made more expeditiouſly, by adding the gum and vitriol to a decoction of galls and logwood in the menſtruum. To the ink, after it has been ſeparated from the feculencies, ſome coarſe powder of galls, from which the fine duſt has been ſifted, together with one or two pieces of iron, may be added, by which its durability will be ſecured.

this ink is not convenient for uſe; becauſe the vitriolic acid, although weakened by water, always injures the paper, and at length deſtroys it.

Amongſt the moſt famous ſympathetic inks is that made with the ſolution of biſmuth in nitrous acid. The inviſible characters written with this ink may be rendered ſenſibly black without being moiſtened or heated but by being expoſed to the contact of phlogiſton reduced into vapors; becauſe this phlogiſton revives the earth of biſmuth, which is partly calcined by the nitrous acid, and even applies itſelf, ſuperabundantly, to that metallic earth, which it blackens ſo much more, as it is in greater quantity.

The phlogiſtic vapors exhaling from liver of ſulphur are the fitteſt for producing this effect upon the ſolution of biſmuth. The authors who firſt deſcribed this ſympathetic ink, required that a ſolution of the ſcoria of regulus of antimony, or of a mixture of quicklime and orpiment, ſhould be employed: but as the former of theſe ſubſtances is an antimoniated liver of ſulphur, and as the latter is an earthy liver of ſulphur, mixed with arſenic, we may perceive that they produce their effects only as being livers of ſulphur. The ordinary liver of ſulphur is found to ſucceed equally well.

When therefore characters written with the ſympathetic ink of biſmuth are required to appear, expoſure to the vapors of liver of ſulphur is ſufficient for that purpoſe; and theſe vapors are ſaid to be capable of producing their effect acroſs a quire of paper, or even a ſtone-wall. This does not appear impoſſible, but it muſt require a long time. We are certain, that the white precipitate of biſmuth, nitrous cryſtals of biſmuth, or of lead, although well covered with paper, become blackened on their ſurfaces by remaining in laboratories where phlogiſtic vapors float, particularly the vapors of liver of ſulphur.

We may eaſily perceive that the writing made by this ink of biſmuth may be more readily made to appear by being moiſtened with a ſolution of liver of ſulphur. (m)

The moſt modern ſympathetic ink, and, at the ſame time, one of the moſt curious, is that made with a ſolution of the regulus or calx of cobalt in aqua regia. The proceſs of this ink has been publiſhed in the Memoirs of the Academy of Sciences by Mr. Hellot.

This proceſs was very troubleſome; becauſe he directed that cobalt itſelf ſhould be employed, which muſt be firſt roaſted; then diſſolved in nitrous acid; and, laſtly, to the ſolution ſome ſea-ſalt muſt be added; and alſo becauſe good cobalt is very ſcarce. But this ink may be eaſily made. For this purpoſe, let the

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(n) Inſtead of the ſolution of biſmuth in nitrous acid, a ſolution of ſugar of lead in water may be employed for the ſame purpoſe; and the writing made with this liquor is rendered black by vapors of liver of ſulphur, or ſtill more effectually by the ſolution of liver of ſulphur in water. But as theſe chemical liquors may require more management than can be conveniently applied, or perhaps comprehended by ſome lovers, and other perſons engaged in myſterious correſpondencies; Ovid, that admirable inſtructor, has recommended a more familiar and domeſtic method of communicating tender ſentiments without danger of diſcovery from fathers or huſbands. This method conſiſts in writing with milk, which, by being held near a fire, is rendered viſible. The juice of lemons has alſo been uſed with great ſucceſs, for the ſame purpoſes, and in the ſame manner. The color given to theſe two laſt mentioned liquors proceeds from a beginning decompoſition of their oily and mucilaginous particles by means of heat. Not only theſe liquors, but all the ſympathetic inks, mentioned by authors, may be rendered more or leſs viſible, by application of heat.

zaffre be taken which is commonly ſold by druggiſts, from which, by digeſtion in aqua regia, may be extracted all that this acid is capable of diſſolving: this ſoluble part of zaffre is the calx of cobalt, which is uſed for giving a blue color to glaſs. This ſolution is then to be diluted with a little common water, to prevent it from making too ſtrong an impreſſion upon paper. Characters written with this diluted ſolution are inviſible when cold, and become of a fine greeniſh-blue when heated; and have this ſingular property, that after they have been rendered viſible by heat, they again diſappear when expoſed to cold, and may thus be made to appear and diſappear alternately, by alternate applications of heat and cold: but care muſt be taken to heat the paper no more than is juſt ſufficient to make the writing appear; for when it is heated too much, the writing will not again diſappear by expoſure to cold.

This ink may be applied to the drawing of landſcapes, in which the earth and trees deſtitute of verdure, being drawn with common ink, give a proſpect of winter; and which may be made to aſſume the appearance of ſpring, by expoſure to a gentle heat, which covers the trees with leaves, and the earth with graſs, by rendering viſible thoſe parts of the landſcapes which are drawn with this ſympathetic ink. This idea has been executed upon fire-ſcreens by an induſtrious artiſt (*n*)

By reflecting a little upon the properties of chemical agents, and on the phenomena of many operations, we may perceive that many new ſympathetic inks with peculiar properties may be diſcovered.

CCCXC. INSTRUMENTS (CHEMICAL). The inſtruments employed in chemical operations are very numerous, and are deſcribed under their ſeveral articles. They are alſo enumerated in a general manner under the article LABORATORY.

CCCXCI. INTERMEDIUM, *or* INTERMEDIATE SUBSTANCE. Thoſe ſubſtances are called *intermediate* by means of which other ſubſtances incapable of uniting together alone, may be united. For example, ſaline, acid, or alkaline ſubſtances, by means of which oils are reduced to a ſaponaceous ſtate, and are thereby rendered miſcible with water, are the intermediate ſubſtances of this union of oil with water; becauſe, without theſe ſaline ſubſtances, oil and water cannot be united, or even well mixed.

Thoſe matters are alſo called intermediate, which are employed to diſunite others, which cannot be otherwiſe diſunited. In this ſenſe vitriolic acid is an intermediate ſubſtance, by which nitrous or marine acids may be ſeparated from any alkaline ſalt, with which they happen to be united.

CCCXCII. IPECACOANHA. (*o*)

CCCXCIII. IRON. Iron, called alſo *Mars*, is a metal of a white, livid, greyiſh color. It is the hardeſt of all metals, the moſt elaſtic, and, ex-

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(*n*) We may obſerve, that a ſolution of regulus of cobalt, or of zaffre, in ſpirit of nitre, acquires a reddiſh color by application of heat. Hence, ſome variety of color might be given to the landſcapes propoſed in the text. Thus while the green ſolution of this ſemi-metal in aqua regia repreſented the leaves, the red ſolution might repreſent the fruits and flowers.

(*o*) IPECACOANHA. From ſixteen ounces of good ipecacoanha, three ounces of reſinous matter were extracted by means of ſpirit of wine; and from the ſame quantity, by means of water, five ounces of gummy matter were extracted. *Neuman.*

cepting platina, the moſt difficult to be fuſed. This metal has, next to gold, the greateſt tenacity of parts; an iron wire, the diameter of which is a tenth part of an inch, being capable of ſuſtaining 450 pounds, without being broken.

Next to tin, iron is the lighteſt of the metals. It loſes when immerſed in water betwixt a ſeventh and an eighth part of its weight. A cubic foot of forged iron weighs 580 pounds.

Very pure iron is ſufficiently ductile to be drawn into wire as fine as horſe-hair. But theſe properties of iron are ſubject to vary much in their degrees, according to the different kinds of iron. This difference proceeds from a quantity, ſometimes greater and at other times leſs, of an earth contained in iron. which is unmetallic, or at leaſt which is not metalliſed, from the great difficulty of fuſing perfectly its ore. *See* Ores *of* Iron *and* Smelting *of* Ores.

Iron is the only known ſubſtance which is attracted by magnets, and capable of becoming itſelf a magnet, ſo as to attract other iron. By this property it may be diſcovered in mixtures where by other methods it could ſcarcely be perceived, and may be even ſeparated, when it is only interpoſed betwixt other bodies, and not adherent to them. It preſerves this property, although it be allayed with ſome other metals. Henkel ſays, in his Pyritologia, that iron allayed with two parts of copper is ſtill magnetical. (*p*)

Iron is a very deſtructible metal. Its ſurface is quickly converted by the combined action of air and water into a ruſt or yellow calx, deprived of all its phlogiſton. This calx is only an earth deprived of metallic properties, and which cannot recover theſe properties, without being again combined with its inflammable principle. The deſtruction of iron expoſed to a moiſt air by ruſt, is univerſally known. The ruſt of iron, and the other calxes of this metal, are called *ſaffron of Mars*, *crocus martis* *See* Saffron *of* Mars.

Water alone, without the help of air, ſeems to be capable of acting upon iron in ſome meaſure, without depriving it indeed of its inflammable principle: but it divides and conſiderably attenuates it; which ſeems to ſhew that this metal contains ſome ſaline parts. *See* Ethiops Martial.

Iron is not fuſible by the heat of ordinary furnaces; but it is eaſily burnt and calcined, by which it is changed into an earthy matter more or leſs reddiſh or blackiſh, called *aſtringent ſaffron of Mars*. *See that word.* This ſaffron of Mars is nothing but the proper earth of iron deprived of the greateſt part of its phlogiſton by calcination.

Iron heated as much as is poſſible, that is, till it becomes of a ſhining white color, and juſt beginning to fuſe, has the appearance of a combuſtible body, penetrated by a vivid and bright flame: and indeed the inflammable principle of this metal heated to that point, really burns in a ſenſible manner. A number of vivid and ſhining ſparks ſhoot out from it, and burn with a kind of decrepitation. I have expoſed iron to the focus of a large burning glaſs, where it quickly fuſed and boiled, and emitted an ardent fume, the

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(*p*) A greatly ſmaller proportion of iron in an allay of copper with that metal, retains its magnetical quality. Gellert affirms, that the magnetical quality of iron is deſtroyed by allaying it with regulus of antimony. He obſerves, that the ſurface of his allay was covered with ſpots like ruſt; which circumſtance induces a ſuſpicion that his iron might have been injured by ſulphur, ſome of which is frequently retained by regulus of antimony.

lower part of which was a true flame. At length it was changed into a blackiſh vitrified ſcoria. The ſparks ſtruck from iron by flints are nothing but bits of iron heated by violent colliſion, and when collected upon paper, and viewed by means of a microſcope, appear to be like ſcoria of iron, or ſlag. (q).

All the acids diſſolve iron, and in their ſolutions exhibit particular phenomena.

If filings of iron be put into a matraſs, and a ſufficient quantity of vitriolic acid added to diſſolve it, the ſolution will be made with heat and efferveſcence. The vitriolic acid, when it diſſolves the iron in this manner, takes from it much of its inflammable principle: for the vapors which exhale from this ſolution have not only a ſtrong ſmell of volatile ſulphureous acid, but they are ſo impregnated with phlogiſton, that they are very inflammable. An experiment may be made to render this truth ſenſible by ſight. Let the mouth of the matraſs be ſtopt by a finger during thirty or forty ſeconds, and a lighted candle be brought very near the mouth when it is to be unſtopped; a flame will then immediately appear within the matraſs, and at the ſame time a ſtrong exploſion will happen. This exploſion would break the matraſs, if the quantity of filings of iron was conſiderable, for inſtance eight or nine ounces, and if the neck of the matraſs was ſtraight. This inflammation and this exploſion may be frequently repeated, when the ſolution is made with ſome activity; and if the matraſs be left unſtopt after the exploſion, and the vapor be kindled, it continues to burn at the mouth of this veſſel with a blue tranquil flame, while the ſolution continues. *See* AIR (FIXABLE INFLAMMABLE), *and* DAMPS.

From the ſolution of iron by vitriolic acid, a vitriolic ſalt with metallic baſis is formed, which by evaporation and cooling is coagulated into green rhomboidal cryſtals. This ſalt is called *martial vitriol*, *green vitriol*, or *green copperas*. See its properties at the article VITRIOL (MARTIAL).

Nitrous acid diſſolves iron moſt actively and violently. This acid cannot ſcarcely be ſaturated with iron; becauſe when it has diſſolved a large quantity of iron, and ſeems to be ſo ſaturated, that ſome of the metal is depoſited under form of martial ſaffron; if more iron be then added, it will be diſſolved, while ſome of that which was before diſſolved will be precipitated.

(q) Iron is a combuſtible ſubſtance, as appears from the great waſte or loſs of quantity obſervable in iron expoſed to a red, but eſpecially to a white heat. This combuſtion is maintained and excited, like that of all other combuſtible ſubſtances, by contact of air. Dr. Hook ſays, that having heated a bar of iron to that degree called white heat, he placed it upon an anvil, and blowed air upon it by means of bellows, by which it burnt brighter and hotter. The ſparks produced by the colliſion of ſteel with flint, appear to be globular particles of iron which have been fuſed, and imperfectly ſcorified or vitrified. They are kindled by the heat produced by the colliſion; but their vivid light, and their fuſion or vitrification, are the effects of a combuſtion continued in theſe particles during their paſſage through the air; and theſe effects are ſo great in ſo ſhort a time, becauſe the quantity of ſurface of theſe minute particles of iron, and conſequently the quantity of air applied to excite the combuſtion, is ſo great in proportion to the quantity of matter. This opinion, that the ignition, light, and fuſion of the ſparks are occaſioned by the heat, excited by the combuſtion of their own inflammable matter, and not merely by the heat communicated by the colliſion, is confirmed by an experiment made and related by Mr. Hawkſbee; from which we find that theſe ſparks ſtruck by colliſion are not viſible, that is, they are not ignited, and do not deflagrate, in an exhauſted receiver; the air being neceſſary to maintain and excite their deflagration and combuſtion.

The cauſe of this phenomenon is, that the nitrous acid takes from the iron much of its phlogiſton during the ſolution, and alſo that iron has ſo much leſs adheſion to nitrous acid, as it is more deprived of phlogiſton. This being eſtabliſhed, we may perceive, that when iron containing its due quantity of phlogiſton is added to nitrous acid ſaturated with a half dephlogiſticated iron, this acid, greedy of the inflammable principle, quits the latter metal, and diſſolves the former.

The vapors of nitrous acid which diſſolves iron are always very red, of a nauſeous ſmell, more diſagreeable, and apparently more volatile, than thoſe of the uncombined acid. This obſervation may be applied to all ſolutions with nitrous acid of thoſe metallic ſubſtances, which are capable of loſing their inflammable principle. Theſe qualities of nitrous acid proceed from the ſuperabundant quantity of phlogiſton, which it imbibes in every ſolution. Experiments might be made to try whether the vapors which exhale from this ſolution, and from ſolutions of ſeveral other metallic ſubſtances abounding in phlogiſton, are inflammable, like thoſe which exhale from a ſolution of iron in vitriolic acid. But theſe experiments ought to be made cautiouſly, leſt exploſions ſhould happen.

Marine acid alſo diſſolves iron with eaſe, and even with activity; but it does not take from the metal its inflammable principle ſo efficaciouſly as nitrous acid does, and even as vitriolic acid, although it does produce ſome change upon it in this reſpect. A great chemiſt affirms, that marine acid treated with iron acquires the properties of nitrous acid. (g)

Aqua regia diſſolves iron with much impetuoſity, and preſents phenomena partaking of thoſe of the ſolutions of this metal in the nitrous, and in the marine acids ſeparately.

Iron forms with the nitrous and marine acids, ſeparately or conjointly, ſalts with metallic baſes, of a deliqueſcent nature.

When ſolutions of iron with any of the mineral acids are made with much ſuperabundant acid, their color is more or leſs green, and they remain clear without making any depoſition: but when the acid is ſaturated with metal, the color of the ſolution is more or leſs yellow or reddiſh, and a certain quantity of yellow ferruginous earth called *ockre* or *ſaffron of Mars* is depoſited. Theſe differences proceed from this cauſe, that iron requires ſo much more acid to keep it diſſolved, as it is more deprived of its phlogiſton.

Laſtly, when ſolutions of iron, not too acid, and particularly when diluted with water, are heated, they become turbid, and immediately depoſite a quantity of ochre, which they would not have depoſited but in a long time, if they had not been heated.

Ochres, or ſaffrons of Mars, which are depoſited from ſolutions of iron, are not ſo ſoluble as iron: they require a much greater quantity of acid, or cannot be again diſſolved, particularly by nitrous acid, but by peculiar management.

Vegetable acids alſo diſſolve iron. The acid of tartar forms with this metal a ſort of vegetable metallic ſalt, or of ſoluble tartar, which is deliqueſ cent; and is called TINCTURE (TARTARISED) *of* MARS; which *ſee*. Martial or vulnerary balls are made by mixing acid of tartar with filings of iron; which being diſſolved in water furniſh a true ſoluble martial tartar, or tartariſed tincture of Mars. *See* BALLS (MARTIAL).

(g) This great chemiſt is Stahl. The experiment has not been confirmed by other chemiſts.

Iron, like other metals, diſſolved in any acid, may be precipitated by abſorbent earths and alkaline ſalts. But this metal, like all others, preſents, when precipitated by fixed alkalis, different phenomena, according to the particular ſtate of the alkali.

If the alkali employed to precipitate iron is as much dephlogiſticated as it can be, the ferruginous precipitate is of the color of ruſt. If this alkali contains any ſuperabundant phlogiſton, a part of this phlogiſton will be transferred to the iron during its precipitation, and will give it an olive color, more or leſs deep. This precipitate may be eaſily and inſtantaneouſly rediſſolved by pouring upon it a quantity of acid ſufficient to ſaturate the alkali, and to diſſolve the precipitate. This precipitate, when dried with proper precaution, (*ſee* ETHIOPS MINERAL) forms an excellent ſaffron of Mars for the uſe of medicine. Laſtly, if an alkali much impregnated, or ſtill better, if ſaturated with phlogiſton, be added, the precipitate will be of a blue color, and will form what is called *Pruſſian blue*. *See* BLUE (PRUSSIAN).

Alkalis act upon iron as upon all other metals, and are even capable of diſſolving it perfectly, when they can ſeize it ſufficiently divided, as Stahl has diſcovered. For this purpoſe a ſolution of iron by nitrous acid is to be poured into good liquid alkali. Immediately afterwards a red precipitate appears, which, upon agitating the alkaline liquor, inſtantly diſſolves, and communicates to the liquor its color. By this method a conſiderable quantity of iron may be diſſolved by an alkali. When this ſolution contains much iron, it is called *martial alkaline tincture of Stahl*. This operation cannot ſucceed but in certain circumſtances. Theſe circumſtances will be mentioned under the article TINCTURE (MARTIAL ALKALINE) *of* STAHL.

When this tincture is well impregnated with iron, a part of the metal is depoſited in form of a very fine yellow brick colored ſaffron of Mars; and at the ſame time the tincture loſes much of its color. All the iron may be quickly ſeparated from it under the ſame form, by ſaturating this alkali with any acid. This ferruginous precipitate is called *Stahl's ſaffron of Mars*. It is rendered ſufficiently ſoluble in acids by the phlogiſton transferred to it from the alkali. *See* SAFFRON *of* MARS.

Iron precipitates metals diſſolved in acids; and theſe precipitates have their metallic form and brilliancy, as all metallic precipitates, which have been ſeparated from the acids of their ſolutions by other metals, have. But iron may be ſeparated from acids by zinc, and by ſome other ſubſtances. *See* PRECIPITATION *and* PRECIPITATE. All vegetable aſtringent ſubſtances, as galls, pomegranate rind, &c. form inks, or black precipitates, with any ſolutions of iron. *See* INK.

Iron has a greater affinity than any other metal with ſulphur: hence it may be employed to ſeparate moſt metals from ſulphur, by fuſion; and ſulphur thus united with iron, conſiderably augments its fuſibility. *See* ESSAYS *of* ORES, *and* REGULUS (MARTIAL) *of* ANTIMONY.

If a bar of iron be heated till it becomes white, and a roll of ſulphur be applied to one of its extremities thus heated, the ſulphur, uniting with the iron, makes it fuſe ſo as to run down in red-hot drops. This experiment ought to be made over an earthen pan filled with water, to receive the melted iron and ſulphur, while they flow down copiouſly, that they may be extinguiſhed as faſt as they fall down, and that their diſſipation may be prevented. In the earthen pan, after this operation, are found ſome parts of pure ſulphur, which had melted without being combined with iron, and which are ſoftened (*ſee* SULPHUR); and other pieces compoſed of iron combined with ſulphur, and which had been fuſed together. Theſe latter pieces are brittle. They are iron artificially mineraliſed, or brought into a pyritous ſtate by ſulphur. *See* PYRITES.

Sulphur and iron act ſo ſtrongly upon each other, that they can mutually diſſolve each other even in the humid way. If five or ſix pounds of filings of iron be mixed with as much powdered ſulphur, and the mixture be moiſtened with a ſufficient quantity of water to form a paſte, this mixture will in a certain time ſwell, become hot, melt, emit vapors, and even take fire. This is an experiment of Mr. Lemery the elder. The reſiduum of this operation furniſhes martial vitriol, which has been produced by a tranſpoſition of acid from the ſulphur to the iron. Here the ſame things happen as in the decompoſition, effervescence, and inflammation of ferruginous pyrites. This union of the acid of vitriol with iron, and the formation of martial vitriol, may be much accelerated by heating and burning the ſulphur, immediately after the mixture. *See* PYRITES, SMELTING *of* ORES, *and* VITRIOL.

As the phlogiſton of iron is copious, and not much engaged, the filings of this metal when heated are capable of detonating with nitre, vividly and briſkly. Hence they are ſaid to be uſed by the Chineſe in their fire-works.

After this detonation, iron is reduced to a reddiſh calx, called *Zwelfer's Saffron of Mars*. *See* SAFFRON *of* MARS.

In whatever manner iron be treated and calcined, the calxes, the ochres, the ruſts, and the precipitates of this metal, are always colored; and the colors of ferruginous earth, in theſe different ſtates, are from the yellow pale of ruſt to a red brown or blackiſh brown. Hence we are induced to believe that martial earth is never entirely deprived of phlogiſton. This is alſo probably the cauſe that all theſe preparations of iron are eaſily ſuſceptible of reſuming phlogiſton, and even in the humid way; for generally metallic calxes reſume phlogiſton ſo much more eaſily, as they have been leſs perfectly deprived of it.

Theſe colors retained by calxes of iron render them fit to be uſed in painting, not only with oil, but alſo to tinge glaſs. Hence they are ſucceſsfully employed for coloring glaſſes or artificial precious ſtones, and for painting different ſhades of red upon pottery, enamel, and porcelain.

Iron may be allayed with all metals excepting lead and mercury, with which it has not yet been rendered capable of uniting. *See* ALLAY and TINNING.

Laſtly, one of the moſt intereſting properties of iron is, that it is capable of being combined either by fuſion or by cementation with a more abundant quantity of phlogiſton; of being converted thereby into a more perfect iron called *ſteel*, which is capable of acquiring by ſudden cooling or tempering a very great hardneſs, which renders it very uſeful for numberleſs neceſſary purpoſes. *See* STEEL.

The affinities of iron are, according to Mr. Geoffroy's table, in the following order: Regulus of antimony, ſilver, copper, and lead. Theſe three laſt are placed ſo as to mark an equal degree of affinity with iron. But we muſt obſerve, that lead ought not to have been placed there, becauſe it has no affinity with iron: but as iron united with ſilver may be inſtantly ſeparated from the ſilver by addition of lead, which unites with the ſilver, and obliges the iron to float upon the ſurface of this new mixture; Mr. Geoffroy ſeems to have meant to have ſhewn this effect in this column of his table of affinities, which however is not very accurate: for this experiment only ſhews, that ſilver quits iron to unite with lead. Mr. Gellert's table of ſolutions gives for the affinities of iron, gold, ſilver, and copper. Lead and mercury might be placed at the bottom of the column, where ſubſtances are mentioned which cannot be united with that which is placed at the head of the column. (*s*)

The uſes of iron are ſo well known, and ſo numerous, that they need not be enumerated. We ſhall only obſerve, that no metal is ſo uſeful. It is, as it were, the ſoul of the arts, and is neceſſary for the exiſtence of them all.

This metal furniſhes alſo very efficacious remedies, the virtues of which are well eſtabliſhed by practice. This is almoſt the only metal which is not virulent. It may be taken internally in ſubſtance, provided it be well divided in form of calx or ſaffron, or even when united with ſome acid, and in a ſaline form, without any danger. It never produces any bad effect, when applied in ſuitable quantity and circumſtances.

The great medicinal virtue of iron is cauſed by its tonic and ſtrengthening qualities. It produces a ſlight and gentle irritation of the fibres, the effect of which is, to conſtringe the ſenſible organic parts upon which it acts, and to encreaſe their force and elaſticity.

Iron particularly acts upon the fibres, and the veſſels of the ſtomach and inteſtines: hence it produces excellent effects in all diſeaſes which proceed from laxity and inactivity of the digeſtive organs; ſuch are crudities, bad digeſtions accompanied with diarrhea, flatulencies, flatulent colics, &c. and in diſeaſes which proceed from the former, as megrims, many hyſterical, hypochondriacal, and melancholic affections, intermittent fevers, tertians and quartans, &c.

Iron has alſo been always conſidered and adminiſtered by the beſt practitioners as a reſolving and aperitive remedy. Stahl, however, and ſeveral other good phyſicians and modern chemiſts, acknowledge no other but the tonic and ſtrengthening qualities of iron. If their opinion be well founded, the caſes in which iron has produced a reſolving and aperitive effect, are ſuch where the obſtructions, and the defect of ſecretions and excretions, have proceeded from weakneſs and re-

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(*s*) Iron like other metals is ſaid to conſiſt of earth, phlogiſton, and a metallic or mercurial principle. Teichmeyer relates an experiment by which the exiſtence of the mercurial principle is pretended to be proved. He ſays, that by diſtilling iron filings, which had been expoſed during a year to the air, then triturated, and afterwards expoſed another year to the air, he had obtained a hard matter which ſtuck to the neck of the veſſel, and along with it ſome mercury.

Concerning the *ſmelting of iron ores*, and the other parts of the *Metallurgical Hiſtory of Iron*, *ſee* SMELTING *of* ORES *of* IRON; *and* STEEL.

laxation of the fibres and of the veſſels, rather than from a craſſitude of humors; as in the chloroſis, in ſome kinds of jaundice, and in other diſeaſes of the ſame ſort.

The excrements of perſons uſing martial remedies are blackiſh, or even black, which proceeds from a mixture of this metal diſſolved with the aliments. This proves, that if iron penetrates farther than the primæ viæ, it muſt be in very ſmall quantity, ſince the greateſt part of it is ejected with the excrements.

As the principal effect of iron is to change the tone, the tenſion, and the ſpring of the ſolid parts of the body, this effect cannot be continued without a continuance of the martial remedy for ſome conſiderable time; otherwiſe only a tranſient relief would be given, and the diſeaſe would ſoon recur.

CCCXCIV. ISINGLASS. (*t*)

CCCXCV. JUICES *of* PLANTS. The juices of ſeveral plants are expreſſed to obtain their eſſential ſalts, and for ſeveral medicinal purpoſes, with intention either to be uſed without further preparation, or to be made into ſyrups and extracts.

The general method of extracting theſe juices is, by pounding the plant in a marble mortar, and then by putting it into a preſs. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we ſhall ſoon obſerve.

The juices of all plants are not extracted with equal eaſe. Some plants even when freſh contain ſo little juice, that water muſt be added while they are pounded, otherwiſe ſcarcely any juice would be obtained by expreſſion. Other plants which contain a conſiderable quantity of juice, furniſh by expreſſion but a ſmall quantity of it, becauſe they contain alſo much mucilage, which renders the juice ſo viſcid that it cannot flow. Water muſt alſo be added to theſe plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method are not, properly ſpeaking, one of their principles, but rather a collection of all the proximate principles of plants which are ſoluble in water; ſuch as the ſaponaceous extractive matter, the mucilage, the odoriferous principle, all the ſaline and ſaccharine ſubſtances; all which are diſſolved in the water of the vegetation of the plants. Beſides all theſe matters, the juice contains ſome part of the reſinous ſubſtance, and the green coloring matter, which in almoſt all vegetables is of a reſinous nature (*u*). Theſe two latter ſubſtances, not being ſoluble in water, are only interpoſed between the parts of the other principles which are diſſolved in the juice, and conſequently diſturb its tranſparency. They nevertheleſs adhere together in a certain degree, and ſo ſtrongly in moſt juices, that they cannot be ſeparated by filtration alone.

(*t*) ISINGLASS is a glue prepared by boiling the ſkin, tail, fins, ſtomach, inteſtines, and bladder of a certain large fiſh frequent in the Ruſſian ſeas and large rivers. It is totally ſoluble in water, but not at all in rectified ſpirit of wine. From eight ounces of iſinglaſs were obtained, by diſtillation, four ounces and two drams of urinous ſpirit, half an ounce of concrete volatile ſalt, an ounce and a half of empyreumatic oil, half a ſcruple of fixed ſalt, and nine drams of earth. Iſinglaſs is employed as a glue for many purpoſes, and for fining wines. *Neuman.*

(*u*) The coloring ſubſtance of vegetables does not ſeem to be a reſinous or gummy matter, but only to adhere accidentally to the reſinous or gummy matters of plants; for when it has been ſeparated from theſe ſo as to form with earth of allum the precipitates called *lakes*, it is not ſoluble either by water or by ſpirit of wine. *See* DYEING.

When therefore theſe juices are to be clarified, ſome previous preparations muſt be uſed by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are ſpontaneouſly clarified by reſt and gentle heat. The juices of moſt antiſcorbutic plants abounding in ſaline volatile principles, may be diſpoſed to filtration merely by immerſion in boiling water; and as they may be contained in cloſed bottles while they are thus heated in a water-bath, their ſaline volatile part, in which their medicinal qualities chiefly conſiſt, may thus be preſerved. Fermentation is alſo an effectual method of clarifying juices which are ſuſceptible of it; for all liquors which have fermented, clarify ſpontaneouſly after fermentation. But this method is not uſed to clarify juices, becauſe many of them are ſuſceptible of only an imperfect fermentation, and becauſe the qualities of moſt of them are injured by that proceſs.

The method of clarification moſt generally uſed, and indiſpenſably neceſſary for thoſe juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and ſeparates it from the juice in form of ſcum, together with the greateſt part of the reſinous and earthy matters which diſturb its tranſparency. And as any of theſe reſinous matters which may remain in the liquor, after this boiling with the whites of eggs, are no longer retained by the mucilage, they may eaſily be ſeparated by filtration. *See* FILTRATION.

The juices, eſpecially before they are clarified, contain almoſt all the ſame principles as the plant itſelf, becauſe in the operation by which they are extracted no decompoſition happens, but every thing remains, as to its nature, in the ſame ſtate as in the plant. The principles contained in the juice are only ſeparated from the groſſer, oily, earthy, and reſinous parts, which compoſe the ſolid matter that remains under the preſs. Theſe juices, when well prepared, have therefore exactly the ſame medicinal qualities as the plants from which they are obtained. They muſt evidently differ from each other as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in thoſe reſpects.

CCCXCVI. IVORY-BLACK. *(x)*

CCCXCVII. JUPITER. By this name the old chemiſts diſtinguiſhed tin. *See* TIN.

(x) *See the article* BLACK.

K.

CCCXCVIII. **KALI.** (y)

CCCXCIX. **KAOLIN.** (z)

CCCC. **KARAT.** This name is applied to the proportional parts which are ſuppoſed to be in any maſs of gold, the value or purity of which is to be aſcertained. When therefore gold is conſidered with regard to its degree of purity, the whole maſs of it, whatever be its real weight, is ſuppoſed to be divided into 24 parts, and theſe parts are called karats. Hence, when gold is entirely pure, and without alloy, it is called gold of 24 karats. If it contains $\frac{1}{24}$ part of alloy, it is called gold of 23 karats, becauſe in ſuch a maſs $\frac{23}{24}$ are gold, and $\frac{1}{24}$ is alloy. If the maſs of gold be $\frac{2}{24}$ or $\frac{1}{12}$ of alloy, it is called gold of 22 karats, and ſo on. For greater preciſion, the karat is ſuppoſed to be ſubdivided into 32 parts, which have no other name than the thirty-ſecond parts of a karat (a). *See* ESSAY *of the* VALUE *of* GOLD *and of* SILVER.

(y) KALI is a maritime plant, from the aſhes of which a conſiderable quantity of mineral fixed alkali is obtained by lixiviation. *See* ALKALI (FIXED MINERAL). Henkel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a conſiderable quantity of ſea-ſalt.

(z) KAOLIN is the name of an earth which is uſed as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by Mr. Reaumur. He found that it was perfectly unfuſible by fire. He believed that it was a talky earth; but the author of this Dictionary juſtly obſerves, that it is more probably an argillaceous earth, from its forming a tenacious paſte with the other ingredient called *petuntſe*, which has no tenacity. Mr. Bomare ſays, that by analyſing ſome Chineſe kaolin, he found it was a compound earth conſiſting of clay, to which it owed its tenacity; of calcareous earth, which gave it a mealy appearance; of ſparkling particles of mica, and of ſmall gravel or particles of quartz cryſtals. He ſays, that he has found a ſimilar earth upon a ſtratum of granite, and conjectures that it may be a decompoſed granite. *See* PORCELAIN.

(a) The karat, or carat, in England is divided into four parts only, called grains, and in Germany into twelve parts. Standard gold in England is gold of twenty-two carats, that is, which contains $\frac{1}{12}$ part of alloy, which is generally an equal mixture of copper and ſilver; as the whole proportion of the copper would make the gold too high-colored, and the whole proportion of the ſilver would make it too pale.

The word karat, when applied to diamonds, ſignifies a real weight of four grains.

CCCCI. KERMES. (*b*)

CCCCII. KERMES MINERAL. Kermes mineral, ſo called from its color, which reſembles that of vegetable kermes, is one of the moſt important antimonial preparations, both with regard to its chemical phenomena and to its medicinal uſes.

The uſe of kermes mineral was not eſtabliſhed in medicine before the beginning of this century. Some chemiſts, indeed, amongſt others Glauber and Lemeri, had before that time mentioned in their works ſeveral preparations of antimony which approach more or leſs to kermes; but theſe preparations being little known, were confounded with many others which are entirely neglected, although much praiſed by their authors.

The fame of kermes was occaſioned by Friar Simon, apothecary to the Chartreux Friars. This friar received this preparation from a ſurgeon called La Ligerie, who had procured it from a German apothecary who had been a ſcholar of the famous Glauber. Friar Simon, from the commendations given to this new remedy by La Ligerie, adminiſtered it to a Chartreux Friar, who was dangerouſly ill of a violent peripneumony, by which the Friar was ſuddenly, and as it had been miraculouſly, cured. From that time the Friar apothecary publiſhed the virtue of his remedy. Several other remarkable cures were performed by means of kermes. The public believed in its medicinal qualities, and called it *Powder of Chartreux*; becauſe it was prepared only in the apothecary's ſhop belonging to theſe monks. The reputation of kermes extended itſelf more and more; till at length the Duke of Orleans, then Regent of France, procured the publication of the proceſs by La Ligerie.

This is the hiſtory of kermes, as it is related by Mr. Baron, in his edition of Lemeri's Chemiſtry. Although the proceſs for making this preparation be very accurately deſcribed in this and other books, we ſhall treat of it in detail, becauſe it is a matter of much importance.

The proceſs for kermes, publiſhed by La Ligerie, conſiſts in boiling, during two hours, pulveriſed crude antimony in the fourth part of its weight of the liquor of nitre fixed by coals, and twice its weight of pure water: at the end of this time the liquor is to be decanted and filtrated, while boiling, through brown paper. It continues clear while it is boiling hot; but when it cools, it becomes turbid, acquires a red brick color, and again becomes clear by the depoſition of a red ſediment, which is the kermes. The boiling may be thrice repeated, and each time the ſame quantity of water is to be added to the antimony, and a fourth part leſs of the liquor of fixed nitre. The ſeveral ſediments from theſe three boilings are to be added together, waſhed with clean water, till the water acquires no taſte; and the kermes is then to be dried. La Ligerie directs, that aqua vitæ ſhall be once or twice poured upon it and burnt, and the kermes dried again.

(*b*) Kermes are excreſcencies formed by inſects on the branches and leaves of the ſcarlet oak. They communicate a red color to water or to ſpirit of wine. Woollen cloth, previouſly dipped in a ſolution of alum and of tartar in water, receives from a decoction of kermes a more durable, but leſs vivid, ſcarlet dye than that uſually procured from cochineal, together with a ſolution of tin.

We now proceed to explain the nature of kermes, and the phenomena of its preparation.

Crude antimony is compoſed of regulus of antimony and common ſulphur, united naturally with each other, as in almoſt all metallic minerals. The fixed alkali with which the crude antimony is boiled, although it is diluted with much water, acts upon the ſulphur of the antimony, and forms with it liver of ſulphur; and as this compound is a ſolvent of all metallic matters, it diſſolves a certain quantity of the regulus of antimony. In this operation then a combination is formed of fixed alkali, of ſulphur, and of regulus of antimony. Of theſe three ſubſtances the fixed alkali only is ſoluble in water, and is the intermediate ſubſtance by which the ſulphur and regulus are ſuſpended in the water. But we are to obſerve, that the alkali becomes impregnated by this operation, and by boiling, with a larger quantity of regulus, and eſpecially of ſulphur, than can be ſuſpended in cold water; hence the decoction of kermes, which is clear, limpid, and colorleſs while boiling hot, becomes turbid, and depoſites a ſediment while it cools. This compound, therefore, like certain ſalts, may be kept diſſolved in larger quantity by hot than by cold water, and much of it is therefore depoſited by cooling.

Further, while the kermes is precipitating, the whole antimoniated liver of ſulphur, which is diſſolved by the boiling liquor, may be divided into two parts; one of which, that is the kermes, being overcharged with the regulus, and particularly with the ſulphur, contains but a little alkali, which it draws along with it during its depoſition. The other part, as it contains much more alkali, remains diſſolved even in the cold liquor, by means of this larger quantity of alkali. All theſe propoſitions are to be explained and demonſtrated by the following obſervations.

Firſt, when the decoction of kermes is cold, and has formed all its ſediment, if, without adding any thing to it, it be heated till it boil, it again entirely re-diſſolves the kermes; the ſediment diſappears; the liquor becomes clear, and by cold is again rendered turbid, and depoſites ſediment as before. Thus the kermes may be made to precipitate and to re-diſſolve as often as we pleaſe.

Secondly, by digeſting kermes in aqua regia, which diſſolves its alkali and regulus, the ſulphur is ſeparated pure. The acids of aqua regia form a nitre and a febrifugal ſalt of Sylvius with the alkali of the kermes; and if a certain quantity of kermes be melted with black flux, after having deſtroyed its ſulphur by roaſting, a true regulus of antimony may be obtained from it.

Theſe experiments, which were made by Mr. Geoffroy, and the detail of which is found in Memoirs given to the Academy in the years 1734 and 1735, upon the Analyſis of Kermes, ſhew evidently the preſence of ſulphur, of fixed alkali, and of regulus of antimony, in this compound. From Mr. Geoffroy's experiments we find, that 72 grains of kermes contain about 16 or 17 grains of regulus, 13 or 14 grains of alkaline ſalt, and 40 or 41 grains of common ſulphur.

Thirdly, by repeating the boiling of the liquor upon the antimony, more and more kermes will be formed each time by cooling, as at firſt; and this experiment may be repeated a great many times. Mr. Geoffroy ſays, that he repeated it 78 times, without any other addition than that of pure water, to ſupply that which was loſt by evaporation; and that each time a conſiderable quantity of kermes was formed by cooling. This experiment proves, that the alkali tranſforms the antimony into kermes by overcharging itſelf with regulus and ſulphur, and at each precipitation the kermes does not retain and take with it but a very ſmall quantity of alkali.

Fourthly, if any acid be poured upon the liquor in which the kermes has been formed, and from which it has been entirely ſeparated by cooling, Mr. Beaumé has obſerved, that this liquor is again rendered turbid, and that a ſecond ſediment is formed of a yellow reddiſh color, which is nothing elſe than golden ſulphur of antimony; that is, regulus of antimony and ſulphur mixed together, but in very different proportions, and with different ſtrengths of union, from thoſe in which they are found in the crude antimony. *See* SULPHUR (GOLDEN) *of* ANTIMONY.

After this precipitation, in the liquor a neutral ſalt is left, which is formed by the contained alkali and the precipitating acid. From this experiment we find, that in the liquor from which the kermes has been depoſited, a conſiderable quantity of antimoniated liver of ſulphur remains, which differs from kermes by containing a much larger proportion of alkali; ſo that it can keep diſſolved the regulus and ſulphur with which it is united, even when the liquor is cold.

From what has been ſaid concerning the manner in which kermes is formed, and the phenomena preſented by this operation, we ought to underſtand well what it conſiſts of. It is evidently nothing elſe than an antimoniated liver of ſulphur, in which the ſulphur predominates, and which contains too little alkali to be ſoluble in water. On this laſt article we may obſerve, that kermes after its ſpontaneous ſeparation, and before it has been waſhed, contains much more alkali than after it has been waſhed; whence, if the kermes has been waſhed with very hot water, a part of it will be re-diſſolved; but as the water always takes away the part which is moſt alkaline, the kermes which remains at laſt contains ſo little alkali, that it is no longer ſoluble even in boiling water; and then it has all the qualities peculiar to it.

In the proceſſes for ſeveral antimonial preparations, a kermes, or compounds like it, are formed. This always happens when crude antimony is treated by fuſion with a quantity of alkaline ſalt, ſo that an antimoniated liver of ſulphur reſults from it, overcharged with regulus and ſulphur; that is, containing more of theſe two ſubſtances than it can keep diſſolved in cold water. If any of theſe combinations be boiled in water, a matter analogous to kermes is always depoſited by cooling. This happens, for inſtance, to the ſcoria of the regulus of antimony, and in an operation deſcribed by Mr. Geoffroy to abridge the proceſs for making kermes by fuſion.

To make kermes by fuſion, Mr. Geoffroy fuſes two parts of antimony with one part of alkaline ſalt; he powders this matter while yet hot, and keeps it during two hours in boiling water; he then filtrates it, and receives the liquor into more boiling water, from which, when it cools, about ſix gros of kermes is depoſited, when an ounce of antimony has been uſed. This method of making kermes is much more expeditious, but leſs perfect; for, as the author confeſſes, the kermes produced is not ſo fine and ſoft as that made in the ordinary method.

Mr. Lemeri the elder mentions alſo, in his Treatiſe concerning Antimony, an operation from which his ſon pretends that kermes may be obtained. This operation conſiſts in digeſting and afterwards boiling powdered crude antimony in a very pure liquor of fixed nitre. This liquor, if it be in ſufficient quantity, is capable of diſſolving quickly and entirely powdered crude antimony, and we cannot doubt but that by cooling a conſiderable quantity of a ſubſtance very analogous to kermes will be produced. Nevertheleſs, none of theſe ſhort methods of making kermes is directed by diſpenſatories, or by the beſt books for deſcribing the preparations of chemical remedies; and we muſt allow, that this is done prudently; for, beſides that all theſe kinds of kermes may be ſuſpected to be leſs fine, or more charged with reguline parts than that which is prepared by the ordinary proceſs; when the conſtant obſervation of medical practitioners has aſcertained the effects of a compound remedy; ſuch a remedy ought to be conſidered as it were conſecrated by a reſpectable kind of empiriciſm, againſt which the fineſt theory and moſt ſpecious reaſonings ought not to avail. The leaſt reformation or innovation ought then to be conſidered as a blameable raſhneſs, particularly when a remedy of ſuch importance is concerned.

Kermes is uſed in medicine only, and from it ſingularly excellent effects may be produced, when adminiſtered by able phyſicians. In kermes are united the citing and evacuant virtues of the emetic preparations of antimony, with the tonic, dividing, aperitive, and reſolving properties of the liver of ſulphur; that is to ſay, that it is capable of anſwering two principal indications in the treatment of many acute and chronic diſeaſes. Properly managed, it may become an emetic, purgative, a diuretic, a ſudorific, or an expectorant, as is required, and it is always attenuating and reſolving. When ſeven or eight grains are taken at once, it chiefly acts upon the primæ viæ, generally as an emetic and as a purgative. A doſe of three or four grains is ſeldom emetic, and more frequently purgative.

When taken in theſe quantities as an evacuant, a little of it paſſes alſo into the viæ ſecundæ & tertiæ. When it is adminiſtered in ſmaller doſes, it paſſes almoſt entirely into the lacteal, blood, and lymphatic veſſels. In theſe it occaſions ſuch ſpaſms and oſcillations as it does in the primæ viæ; ſo that it encreaſes all ſecretions and excretions, but particularly thoſe of urine, ſweat, and expectoration, according to the doſe, to the nature of the diſeaſe, and to the diſpoſition of the patient. It produces ſingularly good effects in thoſe diſeaſes of the breaſt which proceed from fullneſs and obſtruction.

Kermes may be adminiſtered in linctus's, in oily or in cordial potions, in any vehicle; or incorporated in a bolus, with other ſuitable remedies. One precaution, hitherto little obſerved, is very neceſſary, that is, not to join it with acid matters, if it is intended to act as kermes. Anti-acid and abſorbent ſubſtances ought to be joined with it, if the patient has an acid in the primæ viæ, or an aceſcent diſpoſition; for as theſe acids ſaturate the alkali by which the kermes is rendered an antimoniated liver of ſulphur, and by which alone it differs from golden ſulphur of antimony, they accordingly render the kermes entirely ſimilar to the golden ſulphur of antimony, the properties of which are very different from thoſe of kermes. *See* SULPHUR (GOLDEN) *of* ANTIMONY. In ſome caſes, we certainly ought to prefer the unwaſhed kermes to that which has been waſhed, and therefore apothecaries ought to keep both the kinds, as Mr. Baron propoſes in his edition of Lemeri's Chemiſtry.

CCCII. KINGDOMS. Moſt naturaliſts and chemiſts divide all natural bodies into three great claſſes, which they call kingdoms. Theſe are the *mineral*, the *vegetable*, and the *animal kingdoms*.

This great and firſt diviſion is founded on this conſideration, that any plant or vegetable which is produced, which grows, which is organiſed, which contains a ſeed, and which produces its like, ſeems to be a being very diſtinct and different from a ſtone or a metal, in which we at moſt obſerve only a regular arrangement of parts, but not a true organiſation, and which contains no ſeed by which it is capable of reproduction; and another foundation of this diviſion is, that an animal differs no leſs from a ſimple plant, by ſenſation, by the uſe of its ſenſes, and by the power of voluntary motion which it poſſeſſes, while theſe qualities do not belong to any thing which is merely vegetable.

But notwithſtanding theſe marks ſo diſtinctive, ſome philoſophers pretend, that this diviſion into claſſes of natural bodies is only ideal. They affirm, that by obſerving nature attentively, we may perceive that all her productions are connected together by an uninterrupted chain; and that by ſurveying the ſeveral beings, we muſt be convinced that any one being differs very little from ſome other two, betwixt which it ſeems to be placed; ſo that we may deſcend from the moſt perfect animal to the rudeſt mineral by inſenſible degrees, and without finding any interval from which a diviſion might be made.

This idea is certainly great, ſublime, and not improbable; for if we compare a *polypus* with the *ſenſitive plant*, or a *lichen* with a beautiful ore of ramified native ſilver, we ſhall be inclined to conſider this opinion as conformable to the plan of nature.

The opinions of naturaliſts are therefore divided upon this ſubject, and each opinion ſeems to be founded on obſervations, analogies, and reaſonings more or leſs concluſive. But as the diſcuſſion of this matter is foreign to our ſubject, we ſhall not enter into a more particular detail, but we ſhall conſider natural bodies only in a chemical view; that is to ſay, relatively to the ſeveral principles which we obtain in the analyſis of thoſe bodies. We proceed therefore to ſhew what experiments have taught us on this ſubject. In the decompoſition of all beings truly living, organiſed, and containing within themſelves a ſeed by which they may be reproduced, ſuch as vegetables and animals, we always obtain an inflammable, fat, or oily ſubſtance; and on the contrary, we do not find the ſmalleſt trace of this principle in any ſubſtance purely mineral, not even in ſulphur, which is the moſt inflammable of all theſe ſubſtances. On the other ſide, if we carefully examine and compare with each other the analogous principles obtained from the three kingdoms; ſuch as the ſaline ſubſtances obtained in the analyſis of animals, vegetables, and minerals; we ſhall eaſily perceive that all the ſaline matter which comes from the vegetable or animal kingdoms is altered by oil, while all the ſaline matter which comes from the mineral kingdom is entirely free from oil.

We ought to obſerve here, that becauſe any matter is found in one or more individuals of any kingdom, we muſt not therefore conclude, that it belongs to the kingdom of ſuch individuals; for we may be convinced from a ſlight obſervation of nature, that by a thouſand combinations, and particular circumſtances, ſubſtances of quite different claſſes or kingdoms are daily found mixed and confounded together. Thus, for example, within the earth, and even at great depths, that is, in the region appropriated to minerals, ſometimes ſubſtances are found evidently oily, ſuch as all *bitumens*: but we at the ſame time can prove, and all the obſervations of natural hiſtory prove, that theſe oily ſubſtances are only accidentally within the earth, and that they proceed from the vegetable or animal bodies which have been buried in the earth by ſome of thoſe great revolutions which have happened from time to time upon the ſurface of our globe. Alſo in decompoſing ſeveral vegetables and animals, ſalts are obtained; ſuch as common ſalt, Glauber's ſalt, and others, which contain nothing oily, and which are conſequently matters evidently mineral. But, on the other ſide, we are certain that theſe mineral ſalts are extraneous to the animals and vegetables in which they are found; that they are only introduced into theſe living bodies, becauſe they happen to be mixed with the matters which have been applied to them as aliments, and that they ought not to be numbered amongſt their principles. The proof of this is, that not only the quantity of theſe mineral ſalts is not uniform in animals and vegetables, but alſo, that not a particle of ſuch ſalts is contained in ſome plants and animals equally ſtrong and healthy, and of the ſame ſpecies as thoſe in which theſe ſalts have generally been obſerved.

In the ſecond place, we obſerve, that oils do only exiſt in the proximate principles of vegetables and animals; that is, in thoſe of their principles which enter immediately into their compoſition, when theſe principles have not been altered by further decompoſitions, and conſequently when they ſtill preſerve their animal or vegetable character; for, by a natural putrefaction continued during a long time, or by chemical operations, not only the materials of which animal and vegetable bodies are formed, may be deprived entirely of oil, but alſo this oil may itſelf be entirely deſtroyed or decompoſed. Theſe ſubſtances in that ſtate contain nothing by which they can be diſtinguiſhed from minerals. The earths, for example, of vegetables and animals, when they are deprived, by a ſufficient calcination, of all inflammable matter, become entirely ſimilar to the calcareous and argillaceous earths found within the globe, and which may be conſidered as mineral ſubſtances, although probably they have been formerly a part of animal and vegetable bodies. Further, if vegetable acids were deprived of all their oily parts, which is perhaps very poſſible, then they would entirely reſemble the mineral acids, probably the vitriolic and marine, and would loſe all the characteriſtic properties of vegetable acids.

Hence we conclude, that when we conſider natural bodies in a chemical view, we ought to divide them into two great claſſes. The firſt claſs is of ſubſtances inanimate, unorganiſed, and the principles of which have a degree of ſimplicity which is eſſential to them: theſe are minerals. The other claſs contains all thoſe bodies which not only have been diſtinctly organized, but which alſo contain an oily matter, which is no where found in ſubſtances which have not made part of animate bodies, and which, by combining with all the other principles of theſe animate bodies, diſtinguiſhes theſe principles from thoſe of minerals by a leſs degree of ſimplicity. This ſecond claſs contains vegetables and animals. We ought alſo to remark, that the oil contained in vegetable and animal ſubſtances renders them ſuſceptible of fermentation, properly ſo called, which cannot by any means take place in any mineral. *See* ACIDS, BITUMINS, FERMENTATION, OILS, PUTREFACTION, *and* EARTHS.

We ſhall now proceed to examine, if, by comparing the principles obtained in the decompoſition of vegetables with thoſe obtained in the decompoſition of animals, we can find ſome eſſential character by which theſe two kingdoms may be chemically diſtinguiſhed, in the ſame manner as we have ſeen that both of them may be diſtinguiſhed from minerals. From experiments we indeed learn, that the principles of vegetables differ evidently enough from thoſe of animals; that in general the ſaline principles of the former are acid, and are transformable in great meaſure into fixed alkali by incineration, while the principles of the latter are volatile alkalis, or eaſily changeable into theſe; that vegetables are much farther removed from putrefaction than animals; laſtly, that oils truly animal have a character different from vegetable oils, and are in general more attenuated, or at leaſt more diſpoſed to be attenuated and volatiliſed. But we muſt, at the ſame time, confeſs, that theſe differences are not clear and deciſive, like thoſe betwixt theſe two kingdoms and the mineral kingdom; for we do not find any eſſential principle, either in animals or in vegetables, which is not alſo to be found in the other. In ſome plants, chiefly the cruciform, as much volatile alkali, as little fixed alkali, and as much diſpoſition to putrify, are found as in animal matters; and thence we conclude, that if theſe two great claſſes of natural bodies differ chemically from each other, this difference proceeds only from the quantities or proportions of their ſeveral principles and properties, and not from any thing diſtinct and peculiar, nor is it ſimilar to the manner in which both vegetable and animal ſubſtances differ from minerals, namely, by containing an oil, and poſſeſſing a fermentable quality. Beſides, the degrees of the chemical differences betwixt theſe three great claſſes of natural bodies are found to be the ſame, in whatever manner we conſider them or compare them together.

CCCIV. KUPFER-NICKEL. (c)

(c) KUPFER-NICKEL is a reddiſh yellow mineral containing the ſemi-metal called nickel, together with iron and cobalt, mineraliſed by arſenic and by ſulphur. It is ſometimes of a vitreous texture, ſometimes fine-grained, and ſometimes conſiſting of ſcaly particles. *See* NICKEL.

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CCCCV. **LABORATORY** (CHEMICAL). As chemiſtry is a ſcience founded entirely on experiments, we cannot hope to underſtand it well, or to poſſeſs a certain degree of it, without making ſuch experiments as ſhall verify moſt of the known fundamental operations, and alſo ſuch as reaſoning, analogy, and the ſpirit of inquiry, never fail to ſuggeſt to thoſe whoſe taſte and ſuitable talents lead them to this eſſential part of experimental philoſophy. Beſides, when a perſon himſelf obſerves, and operates, he muſt perceive, even in the moſt common operations, a great variety of ſmall facts, which muſt neceſſarily be known, but which are not mentioned either in books or in memoirs, becauſe they are too numerous, and would appear too minute. Laſtly, how many qualities are in the ſeveral chemical agents, of which no juſt notion can be given by writing, and which are perfectly well known as ſoon as they have been once made to ſtrike our ſenſes?

Whoever therefore would become a chemiſt, muſt indiſpenſably have a laboratory furniſhed with the moſt neceſſary inſtruments for the practice of this ſcience; and we therefore think proper to mention what theſe are. Our intention is not to ſpeak in this article of laboratories deſigned for operations in the great, nor of thoſe which are appropriated to ſome particular part of chemiſtry; as, for example, to eſſays, enamels, &c. but of the kind of laboratory which is proper for a philoſophical chemiſt, to make occaſionally, in ſmall, any chemical operation whatever. Such a laboratory neceſſarily occaſions certain expences, but not ſo much as is generally believed, when the operator knows how to manage his utenſils, and to employ only the proper quantity of the ſeveral ſubſtances upon which he operates; and laſtly, when he chuſes the leaſt expenſive methods of attaining his purpoſes.

Many people think, that a laboratory level with the ground is moſt convenient, for the ſake of water, pounding, waſhing, &c. It certainly has theſe advantages; but it is alſo ſubject to a very great inconvenience from moiſture.

Conſtant moiſture, tho' not very conſiderable and ſenſible in many reſpects, is a very great inconvenience in a chemical laboratory. In ſuch a place, moſt ſaline matters become moiſt in time; the inſcriptions fall off, or are effaced; the bellows rot; the metals ruſt; the furnaces moulder, and every thing almoſt ſpoils. A laboratory therefore is more advantageouſly placed above than below the ground, that it may be as dry as is poſſible. The air muſt have free acceſs to it, and it muſt even be ſo conſtructed, that, by means of two or more oppoſite openings, a current of air may be admitted to carry off any noxious vapors or duſt.

In the laboratory a chimney ought to be conſtructed, ſo high that a perſon may eaſily ſtand under it, and as extenſive as is poſſible; that is, from one wall to another. The tube of this chimney ought to be as high as is poſſible, and ſufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no ſoot is collected in it; and therefore it need not be ſo wide as to allow a chimney-ſweeper to paſs up into it.

Under this chimney may be conſtructed ſome brick-furnaces, particularly a melting furnace, a furnace for diſtilling with an alembic, and one or two ovens like thoſe in kitchens. The reſt of the ſpace ought to be filled up with ſtands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. Theſe furnaces are the moſt convenient, from the facility of diſpoſing them at pleaſure; and they are the only furnaces which are neceſſary in a ſmall laboratory. A double bellows of moderate ſize muſt alſo be placed as commodiouſly under the chimney, or as near as the place will allow. Theſe bellows are ſometimes mounted in a portable frame; which is ſufficiently convenient when the bellows is not more than eighteen or twenty inches. Theſe bellows ought to have a pipe directed towards the hearth where the forge is to be placed.

The neceſſary furnaces are, the ſimple furnace, for diſtilling with a copper alembic; a lamp furnace; two reverberatory furnaces, of different ſizes, for diſtilling with retorts; an air or melting furnace; an eſſay furnace, and a forge-furnace. *See the enumeration and deſcription of theſe furnaces under the words* FORGE *and* FURNACE. *See alſo* PLATES.

Under the chimney, at a convenient height, muſt be a row of hooks driven into the back and ſide walls; upon which are to be hung ſmall ſhovels, iron pans; tongs; ſtraight, crooked, and circular pincers; pokers; iron rods, and other utenſils for diſpoſing the fuel and managing the crucibles.

To the walls of the laboratory ought to be faſtened ſhelves of different breadths and heights; or theſe ſhelves may be ſuſpended by hooks. The ſhelves are to contain glaſs veſſels, and the products of operations, and ought to be in as great a number as is poſſible. In a laboratory where many experiments are made, one cannot have too many ſhelves.

The moſt convenient place for a ſtone or leaden fountain to contain water is a corner of the laboratory, and under it a ciſtern ought to be placed with a pipe by which the water poured into it may diſcharge itſelf. As the veſſels are always cleaned under this fountain, cloths and bottle bruſhes ought to be hung upon hooks faſtened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, ſolutions, precipitations, ſmall filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory, are to be placed blocks of wood upon mats; one of which is to ſupport a middle-ſized iron mortar, another to ſupport a middle-ſized marble, or rather hard-ſtone mortar, a third to ſupport an anvil. Near the mortars are to be hung ſearces of different ſizes and fineneſs; and near the anvil are hung a hammer, files, raſps, ſmall pincers, ſciſſars, ſheers, and other ſmall utenſils, neceſſary to give metals a form proper for the ſeveral operations.

Two moveable treſtles ought to be in a laboratory, which may ſerve to ſupport a large filter mounted upon a frame, when it is required. This apparatus is removed occaſionally to the moſt convenient place. *See* FILTRATION *and* FILTER.

Charcoal is an important article in a laboratory; and it therefore muſt be placed within reach: but as the black duſt which flies about it whenever it is ſtirred is apt to ſoil every thing in the laboratory, it had better be in ſome place near the laboratory, together with ſome furze, which is very convenient for kindling fires quickly. This place ſerves, at the ſame time, for containing bulky things which are not often wanted; ſuch as furnaces, bricks, tiles, clay, fire-clay, quicklime, ſand, and many other things neceſſary for chemical operations.

Laſtly, a middle-ſized table, with ſolid feet, ought to be enumerated amongſt the large moveables of a laboratory, the uſe of which is to ſupport a porphyry, or levigating ſtone, or rather a very hard and denſe grit-ſtone, together with a grinder made of the ſame kind of ſtone.

The other ſmall moveables or utenſils of a laboratory are, ſmall hand-mortars of marble, iron, and glaſs, and their peſtles; earthen, ſtone, metal, and glaſs veſſels; *an enumeration of which ſee under the article* VESSELS, *and a deſcription under their reſpective names.*

Some white writing-paper, and ſome paper not glued for filtrations; a large number of clean ſtraws, eight or ten inches long, for ſtirring mixtures in glaſſes, and for ſupporting paper filters placed in glaſs funnels.

Glaſs tubes for ſtirring and mixing corroſive liquors; ſpatulas of wood, ivory, metal, and of glaſs.

Thin paſteboards and horns, very convenient for collecting matters bruiſed with water upon the levigating ſtone or in mortars; corks of all ſizes; bladders and linen ſtrips for luting veſſels. *See* LUTES.

A good portable pair of bellows; a good ſteel, for ſtriking fire; a glue pot, with its little bruſh; laſtly, a great many boxes of various ſizes, for containing moſt of the above-mentioned things, and which are to be placed upon the ſhelves.

Beſides theſe things, ſome ſubſtances are ſo neceſſary in moſt chemical operations, that they may be conſidered as inſtruments neceſſary for the practice of this ſcience. Theſe ſubſtances are:

All metals and ſemi-metals, which ought to be very pure.

Vitriolic acid, ſome of which ought to be concentrated and rectified, and alſo ſome of that ſort commonly ſold by druggiſts.

Aqua fortis, ſuch as is commonly ſold, and is cheap; alſo ſpirit of nitre moderately ſtrong, but very pure: the ſame acid very pure, concentrated, and ſmoking.

Common ſpirit of ſalt. Some of the ſame acid very pure, very ſtrong, and ſmoking. All theſe acids ought to be kept in cryſtal glaſs bottles, and cloſed with glaſs ſtoppers.

Some diſtilled vinegar, which may be kept in an ordinary bottle; ſome radical vinegar, which ought to be kept in a bottle with a glaſs ſtopper; ſome cream of tartar, in an earthen or glaſs veſſel, or in a box.

Common fixed vegetable alkali, very dry, ſuch as pot-aſh, which muſt be kept in a well cloſed bottle. The ſame alkali in a liquid ſtate.

Very pure ſalt of tartar, ſome dry, and ſome liquid.

Mineral alkali, liquid; that is, a ſolution of ſoda. The ſame alkali dry and very pure; that is, well formed cryſtals of ſoda.

The two fixed alkalis liquid, and rendered cauſtic by quicklime. Alkalis, particularly thoſe which are cauſtic, ought to be kept in bottles with glaſs ſtoppers. Some phlogiſticated fixed alkali, or even ſaturated ſo as to be fit for making Pruſſian blue.

Some dry liver of ſulphur kept in a well cloſed bottle. The ſame liquid. Some common ſulphur.

Very pure alkali of ſal ammoniac, diſengaged by a fixed alkali, ſome ſolid, and ſome liquid, kept in a bottle with a glaſs ſtopper.

Fluor ſpirit of ſal ammoniac diſengaged by quicklime, as ſtrong as is poſſible. Some of this ſpirit may be kept of leſs ſtrength.

Lime water, and quicklime, in well cloſed bottles.

The pureſt and higheſt rectified ſpirit of wine.

Good vitriolic ether.

Rectified eſſential oil of turpentine; oil of olives; ſoap.

Galls; ſyrup of violets; tincture of turnſol, or turnſol in rags; fine blue paper; river or diſtilled rain-water.

Beſides theſe ſubſtances, moſt of which are ſolvents, certain neutral ſalts ought to be had which are frequently uſed in chemical operations, or are difficultly prepared. Theſe are:

Vitriolated tartar; alum, and calcined alum; green vitriol; blue vitriol; nitre; decrepitated common ſalt; ſome of the ſame ſalt very pure diſſolved in diſtilled water; purified ſal ammoniac; calcined borax; ſedative ſalt.

A pure ſolution of ſilver in ſpirit of nitre; a ſolution of mercury in the ſame acid; butter of antimony. All theſe to be kept in bottles with glaſs ſtoppers. Corroſive ſublimate.

Ceruſs; litharge; minium; ſand waſhed and ground; white marble; waſhed chalk; glaſs of lead; glaſs of borax. *See the nature and properties of all theſe matters under their reſpective names.*

A perſon, provided with the above-mentioned inſtruments and ſubſtances, may at once perform any chemical experiment. He may indeed occaſionally want ſeveral neutral ſalts which have not been named; but all theſe ſalts with baſes of earths, metals, fixed or volatile alkalis, may be eaſily and inſtantly prepared, as moſt of them do not require diſtillation or ſublimation. They may nevertheleſs, if they are not too numerous, be all previouſly prepared and kept ready for any occaſions.

We ought not to finiſh this article without making ſome obſervations important to thoſe who propoſe to give themſelves up to the ſtudy of chemiſtry. They ought to be well perſuaded that method, order, and cleanlineſs, are eſſentially neceſſary in a chemical laboratory. Every veſſel and utenſil ought to be well cleanſed as often as it is uſed, and put again into its place: inſcriptions ought to be faſtened upon all the ſubſtances. Theſe cares, which ſeem to be trifling, are however very fatiguing and tedious; but they alſo are very important, though frequently little obſerved. When a perſon is keenly engaged, experiments ſucceed each other quickly; ſome ſeem nearly to decide the matter, and others ſuggeſt new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he ſhall eaſily know again the products of the firſt experiments, and therefore he does not take time to put them in order: he proſecutes with eagerneſs the experiments which he has laſt thought of; and, in the mean time, the veſſels employed, the glaſſes and bottles filled, to accumulate, that he cannot any longer diſtinguiſh them; or, at leaſt, he is uncertain concerning many of his former products. This evil is encreaſed if a new ſeries of operations ſucceed, and occupy all the laboratory; or if he is obliged to quit it for ſome time: every thing then goes into confuſion. Thence it frequently happens that he loſes the fruits of much labor, and that he muſt throw away almoſt all the products of his experiments.

The only method of avoiding theſe inconveniences is to employ the cares and attentions above-mentioned. It is indeed diſagreeable to ſtop continually in the middle of the moſt intereſting reſearches, and to employ a very precious and conſiderable time in cleaning veſſels, arranging them, faſtening inſcriptions on them, &c. Theſe employments are capable of cooling or retarding the progreſs of genius, and are tedious and diſguſtful; but they are nevertheleſs neceſſary. Thoſe perſons whoſe fortune enables them to have an aſſiſtant operator, on whoſe exactneſs and intelligence they can depend, avoid many of theſe diſagreeable circumſtances; but they ought nevertheleſs to attend to the execution of theſe things. We cannot depend too much on ourſelves in theſe matters, however minute, on account of their conſequences. This becomes even indiſpenſable when the experiments are to be kept ſecret, at leaſt for a time; which is often neceſſary in chemiſtry.

When new reſearches and inquiries are made, the mixtures, reſults, and products of all the operations ought to be kept a long time, diſtinctly labelled and regiſtered; for theſe things, when kept ſome time, frequently preſent phenomena that were not at all ſuſpected. Many fine diſcoveries in chemiſtry have been made in this manner, and many have certainly been loſt by throwing away too haſtily or neglecting the products.

Laſtly, we cannot too much recommend to chemical operators to be exceedingly upon their guard againſt impoſing and deceitful experiments, which frequently preſent themſelves in practice. A circumſtance ſeemingly unimportant, or not eaſily perceptible, is frequently ſufficient to give the appearance of a great diſcovery, by means of certain effects, which, nevertheleſs, are found to proceed from ſome other cauſe. Chemical experiments depend on ſo many acceſſary things, that all of them can ſeldom be attended to, particularly when the ſubject is new: hence we frequently find that very different reſults proceed from the ſame experiment, made at different times. We therefore muſt not decide after the firſt ſucceſs; but the experiment muſt be repeated ſeveral times, and even varied, till no doubt can remain.

Further, as chemiſtry offers many views for the improvement of many important arts; as it preſents proſpects of many uſeful and profitable diſcoveries; thoſe who apply their labors in this way ought to be exceedingly circumſpect not to be led into an uſeleſs expence of money and time. Thoſe reſearches which have ſome analogy with the philoſopher's ſtone, from the hopes of wealth which they ſuggeſt, are alſo attended with ſimilar danger. In a certain ſet of experiments ſome one is generally of an impoſing appearance, although in reality it be nothing more. Chemiſtry is full of theſe half-ſucceſſes, which ſerve only to deceive the unwary, to multiply the number of trials, and to lead to great expence before the fruitleſſneſs of the ſearch be diſcovered. By theſe reflexions we do not intend to divert from all ſuch reſearches thoſe whoſe taſte and talents render them fit for them; on the contrary, we acknowledge that the improvement of the arts, and the diſcovery of new objects of manufacture and commerce, are undoubtedly the fineſt and moſt intereſting part of chemiſtry, and which make that ſcience truly valuable; for without theſe ends what would chemiſtry be but a ſcience purely theoretical, capable of employing only ſome abſtract and ſpeculative minds, but uſeleſs to ſociety? We acknowledge alſo, that the ſucceſſes in this kind of chemical inquiry are not rare; and that their authors have ſometimes acquired fortunes, ſo much the more honorable as being the fruits of their talents and induſtry. But we repeat, that in theſe reſearches, the more dazzling and near any ſucceſs appears, the more circumſpection and even diſtruſt is neceſſary.

CCCCVI. LAC LUNÆ. (d)

CCCCVII. LAC. (e)

CCCCVIII. LAPIS INFERNALIS. *See* CAUSTIC.

(d) LAC LUNÆ, *Agaricus Mineralis*, is a very light, ſpongy, friable, and white calcarcous earth. *See* EARTH (CALCAREOUS).

(e) LAC, *Lacca*, or *Gum-lac*, is a kind of wax, of which a ſpecies of winged ants form cells upon trees, like honeycombs. In theſe cells remain ſome of the dead inſects, which give a red color to the whole ſubſtance of the lac. That called *ſtick-lac* is the wax adhering to ſome of the ſmall branches of the tree, and which is unprepared. This lac, when ſeparated from the adhering ſticks, and groſsly powdered, and deprived of its color by digeſtion with menſtruums, for the ſake of dyes, and other purpoſes, is called *ſeed-lac*; and laſtly, when the ſtick-lac is freed from impurities, by melting it over a gentle fire, and formed into cakes, it is called *ſhell-lac*. Lac is unſoluble in water, and difficultly ſoluble in ſpirit of wine, which for that purpoſe muſt be well dephlegmated. According to Neuman, ſixteen ounces of ſeed-lac, diſtilled in an open fire, yielded nine ounces and ſix drams of a butter or thick oil, one ounce ſix drams of a watery liquor neither acid nor alkaline, and a reſiduum weighing two ounces and a half. It is uſed in the preparation of ſpirit varniſhes, for the making of ſealing-wax, and as a coloring material for dying ſcarlet. The color given by lac is leſs beautiful, but more durable, than that given by cochineal. To render the coloring matter of the lac diffuſible in water, ſo as to be applied to the ſtuffs to be dyed, Mr. Hellot directs the following proceſs: Let ſome powdered gum-lac be digeſted during two hours in a decoction of comfrey root, by which a fine crimſon color is given to the water, and the gum is rendered pale or

CCCCIX. LAPIS LAZULI. (*f*)

CCCCX. LEAD. Lead, called alſo *Saturn*, is an imperfect metal, white, but darker than tin, the ſofteſt, leaſt ductile, leaſt elaſtic, and leaſt ſonorous of all the metals.

It alſo has the leaſt tenacity; a leaden wire of $\frac{1}{10}$ of an inch in diameter being capable of ſupporting only $29\frac{1}{4}$ pounds.

This metal has a conſiderable ſpecific gravity. Next to gold, platina, and mercury, it is the heavieſt metal. It loſes, when immerſed in water, betwixt $\frac{1}{11}$ and $\frac{1}{12}$ part of its weight. A cubic foot of lead weighs 828 pounds.

ſtraw-colored. To this tincture, poured off clear, let a ſolution of alum be added; and when the coloring matter has ſubſided, let it be ſeparated from the clear liquor, and dried. It will weigh about $\frac{1}{5}$ of the quantity of lac employed. This dried fecula is to be diſſolved or diffuſed in warm water, and ſome ſolution of tin is to be added to it; by which it acquires a vivid ſcarlet color. This liquor is to be added to a ſolution of tartar in boiling water; and thus the dye is prepared.

(*f*) Lapis Lazuli is a blue ſtone, generally intermixed with white veins and gold-colored ſpots. Wallerius conſiders this ſtone as a ſpecies of jaſper; and Cronſtedt, more juſtly, as a ſpecies of that order of earths which have been lately called zeolites. *See* Zeolites. Mr. Margraaf, and alſo Mr. Cronſtedt, have made experiments on this ſtone, carefully cleanſed from all white, pyritous, or heterogeneous matters. From theſe experiments we learn, 1. That this ſtone is ſoluble in acids without effervescence; and when it has been previouſly calcined, it forms gelatinous maſſes with acids. 2. That by calcination it is not deprived of its blue color, till at leaſt that operation has been long continued. 3. By a violent fire it is fuſible, and forms a frothy glaſs, ſometimes whitiſh, and ſometimes of a duſky yellow color, but always clouded with blue ſpots. 4. Fuſed with nitre, and thrown red-hot into [illegible], it tinged the water with a blue colo[illegible]ich diſappeared in ſome hours. By this operation the ſtone loſt its blue color. 5. Some of this ſtone, powdered and mixed with glaſs frit, produced a tranſparent c[illegible] glaſs. With borax, it produced a [illegible] a chryſolite-color. 6. It gave no [illegible] its containing copper, notwith[illegible] has been conſidered as an ore of copper by moſt authors. 7. It ſhewed marks of iron, by forming a blue precipitate, like Pruſſian blue, when a phlogiſticated alkali was added to a ſolution of this ſtone in acids. 8. Margraaf ſays, that by adding vitriolic acid to ſolutions of this ſtone in nitrous and marine acids, a white precipitate was formed, which he ſuppoſes was calcareous earth. Nevertheleſs, Mr. Cronſtedt affirms, that this ſtone does not effervesce with acids. Perhaps the calcareous earth was not eſſential, but only accidental. 9. Cronſtedt ſays, that a precipitate is formed by adding a fixed alkali to a ſolution of this ſtone in vitriolic acid, which, being ſcorified with borax, yields a regulus of ſilver. He ſays, that by ſcorification with lead, two ounces of ſilver have been obtained from a hundred pounds of the ſtone. Mr. Margraaf does not mention that he found any ſilver, or that he ſearched for any. Perhaps it is only accidental.

The fine blue ſubſtance called *ultramarine* is prepared from lapis lazuli in the following manner, according to Wallerius. The ſtone, firſt finely levigated and mixed with linſeed oil, is to be added to a paſte, made by mixing together equal parts of yellow wax, colophony, pitch, that is, half a pound of each, with half an ounce of linſeed oil, two ounces of turpentine, and two ounces of maſtic. To three or four parts of this paſte one part of the levigated ſtone, mixed with linſeed-oil, is to be added; and after the mixture has been digeſted together during three or four weeks, it is to be thrown into hot-water, and ſtirred till the blue color ſeparates and diffuſes in the water, which is then to be poured off. The blue matter is allowed to ſettle; and, when dry, is the ultramarine required.

Like all imperfect metals, it has its peculiar ſmell and taſte. When it is cut by a very ſharp inſtrument, its ſurface appears ſmooth, compact, and ſhining; but it quickly tarniſhes in the air, and its ſurface becomes covered by a ſlight greyiſh ruſt. It reſiſts nevertheleſs much longer than iron or copper the combined action of air and water, before it is decompoſed and deſtroyed. It is very fuſible, and melts nearly with the ſame degree of heat as tin; that is, before it is red.

As ſoon as it melts, even with the leaſt heat that is requiſite, it calcines; and upon its ſurface greyiſh aſhes are formed, in the ſame manner as tin is calcined.

The color, ſoftneſs, fuſibility and calcinability of lead being ſimilar to theſe qualities in tin, perſons acquainted with only the common and ſuperficial qualities of metals ſuppoſe that a great analogy ſubſiſts between lead and tin; nevertheleſs, we ſhall ſhow that the properties of theſe two metals are eſſentially different.

The grey calx, or aſhes of lead, ſimilar externally to thoſe of tin, become of a very different appearance, if the calcination with a fire ſo moderate that it cannot melt them be continued, and particularly if they be expoſed to flame. Inſtead of becoming more and more white, they acquire at firſt a yellow color, and are then called *maſſicot*, or *yellow lead*. The color becomes more and more intenſe, and at laſt entirely red. It is then called *minium*, or *red lead*; *which ſee*. If inſtead of calcining this calx with a gentle fire, it be fuſed, it then eaſily melts into a yellow vitrified ſubſtance, compoſed of ſmall ſcales like thoſe of talk. Lead in this ſtate is called *litharge*; *ſee* that word. This happens in the operation of *cupellation*. Laſtly, if calx of lead be heated more than is neceſſary to keep it in fuſion, it then ſoon changes into a true glaſs, which becomes ſo active and fluid, that it paſſes like water through the moſt compact crucibles. Lead thus calcined and melted is called *glaſs of lead*, becauſe in fact it has the tranſparency, brittleneſs, and all the eſſential properties of glaſs. It is very uſeful in many arts, as may be ſeen under the article Glass *of* Lead.

Of all the metallic calxes, that of lead is the moſt fuſible, and moſt eaſily convertible into glaſs; in which reſpect it differs eſſentially from the calx of tin, which is very refractory.

This difference proceeds from the total privation which tin ſuſtains of all its phlogiſton, and from its capacity of a radical or perfect calcination. Whereas lead, although it loſes, as eaſily as tin does, as much of its phlogiſton as is neceſſary to deſtroy its metallic appearance, and to calcine or vitrify it; yet it retains enough of its phlogiſton to preſerve a great fuſibility, and even a conſiderable denſity: For all the calxes and glaſſes of lead are very heavy.

All theſe calxes and glaſſes of lead are eaſily revivable. They can ſcarcely be melted but ſome part of the lead is revived, although no inflammable matter has been added. This alſo is a proof that they retain much phlogiſton. For, in general, all metallic calxes are ſo much more eaſily reducible as they retain more of their inflammable principle.

Lead is ſoluble by all acids, and preſents with them phenomena ſimilar to thoſe of ſilver with the ſame acids. Lead combined to ſaturation with nitrous acid forms, as ſilver does, a cryſtallizable nitrous ſalt with metallic baſe, called *nitre of lead*. This ſalt is capable of decrepitating, and even of detonating without addition of inflammable matter, as ſeveral chemiſts pretend. This detonation muſt therefore proceed from the phlogiſton retained by the lead, which is ſufficiently combuſtible for that purpoſe. Kunkel, who ſeems not to have known this property of nitre of lead, relates, in his Treatiſe on the Art of making Glaſs, that when he attempted to diſtil this ſalt, his retort was ſuddenly burſt with great noiſe and danger.

Several chemiſts, among others Becker in his Second Supplement to the *Phyſica Subterranea*, and Kunkel in his *Laboratorium Chemicum*, give proceſſes by which mercury may be obtained from lead. Mr. Groſſe, who mentions theſe proceſſes in the Memoirs of the Academy, gives one himſelf, which is more ſimple and more eaſily tried, ſince it conſiſts only in ſaturating perfectly ſome good nitrous acid with lead. By means of this ſaturation a grey powder is precipitated, according to this chemiſt, in which mercury is found. But this proceſs probably does not ſucceed with every kind of lead; for Meſſrs. Macquer and Beaumé ſay, in their Courſe of Chemiſtry, that they have repeated with all poſſible attention this experiment of Mr. Groſſe, without having obtained mercury.

Pure vitriolic acid, and that contained in neutral vitriolic ſalts, when mixed with a ſolution of lead in nitrous acid, unites with the lead, ſeparates it from the nitrous acid, and forms with it a metallic ſalt, or vitriol of lead, which cryſtallizes, and appears therefore in form of a white precipitate, when the liquors do not contain a ſufficient quantity of water to diſſolve it. This ſalt is the ſame as that made by diſſolving directly lead in vitriolic acid.

Marine acid, and all the neutral ſalts containing it, precipitate alſo lead from its ſolution in nitrous acid, and unite with it, forming a metallic ſalt called *plumbum corneum*, from the many reſemblances that it has with the combination of ſilver with marine acid, called *luna cornea*. Plumbum corneum differs from luna cornea in being much more ſoluble in water, which ſhews an abundancy of marine acid, or that it is leſs intimately combined in the lead than in the luna cornea. Plumbum corneum may be made by ſeveral other methods, and particularly by diſengaging the volatile alkali from ſal ammoniac by lead; for, like all other metals, it has the property of decompoſing this ſalt. By this method, Mr. Margraaf makes the plumbum corneum which he employs in the preparation of phoſphorus.

Several chemiſts affirm that the ſolution of lead in nitrous acid may be decompoſed by water ſingly, and that a magiſtery of lead may be thus formed, in the ſame manner as that of biſmuth. But Mr. Beaume, who has examined the affair with greater accuracy, found that this precipitation does not happen when very pure, that is, diſtilled water is uſed; and that conſequently this precipitation is to be attributed to the ſalts, and particularly to the ſelenites, contained in almoſt all ordinary waters.

Vegetable acids alſo diſſolve lead with eaſe; but only the combinations of this metal with vinegar are known, becauſe theſe are uſed in medicine and in the arts. The firſt of theſe preparations is called *ceruſs*, or *white-lead*. It is a kind of ruſt of lead, of an admirable white color, made by the acid of vinegar, to the vapor of which the lead is expoſed. The chief uſe of this preparation is for painting in oil; and is the only white hitherto diſcovered for that purpoſe, although it has two very great faults. The firſt is, that it gives painful colics to perſons employed in its preparation; and the ſecond is, that it is liable to become yellow or black, and, in a word, to loſe much of its beauty in time; which proceeds from the diſpoſition which this calx of lead, like all the other preparations of this metal, has to recover its phlogiſton, and conſequently its color. The diſcovery therefore of another white, poſſeſſed of the beauty and other advantages of white-lead, without its inconveniencies, would be of important ſervice to painting, and even to mankind. *See* CERUSS.

Ceruſs contains too little of the acid of vinegar to be in the ſtate of a neutral ſalt; but as it is lead much opened and divided, it may be eaſily completely combined to ſaturation with this acid. For this purpoſe ceruſs muſt be digeſted with a ſufficient quantity of diſtilled vinegar, to diſſolve it perfectly. The liquor after this ſolution is called *vinegar of lead*. If it be filtrated, evaporated, and cryſtallized, fine cryſtals are formed, capable of a perfect ſolution in water, of a ſaline, metallic, and ſaccharine taſte, from which this ſalt is called *ſugar* or *ſalt of lead*. Salt of lead may be decompoſed merely by the action of fire. By diſtillation a very concentrated acid of vinegar may be obtained from it, a kind of radical vinegar, ſimilar to that obtained from cryſtals of copper. *See* SALT *of* LEAD.

Oils and fat matters, which in general are capable of acting upon metallic ſubſtances, have a diſtinguiſhed action upon lead, and particularly upon its calxes. In conſequence of this action, ceruſs, minium, and litharge, may be entirely and copiouſly diſſolved in moſt oils by coction with moderate heat. Oils in which lead has been diſſolved are thereby rendered thick and drying. Linſeed oil thus thickened by lead is much uſed in painting. The painters call it *drying oil*. So large a quantity of calx of lead may be diſſolved in oils, that a body is thence formed, which when cold is ſolid, tenacious, and of the conſiſtence of plaſters. The conſiſtence of many of the plaſters uſed in ſurgery is cauſed by calxes of lead diſſolved in oils. Theſe maſſes of lead combined with oil, or plaſters, reſemble ſoap in ſmell, rancid taſte, milkineſs given to water, and laſtly, in being decompoſed by acids, which unite with the lead, and ſeparate the oil from it. Theſe obſervations were made by Mr. Geoffroy.

Lead is eaſily united to ſulphur, and is eaſily burnt and calcined by expoſing it at once to the action of ſulphur, fire, and air. With ſulphur alone it forms a compound reſembling the ore of lead, or lead naturally mineralized by ſulphur.

This metal eaſily unites with all metals excepting iron, with which it cannot by any means be allayed. Such is the antipathy of theſe two metals, that if ſilver allayed with ſome iron be melted with lead, the lead preciſely ſeizes the ſilver, and the iron floats upon the ſurface of the melted metals. Nevertheleſs the calxes of lead and iron are very well united together by fuſion, and the former facilitates the vitrification of the latter as much as it does that of the calxes of other metals. Hence lead may be employed to purify the perfect metals from iron, as well as from other imperfect metals. Of all the allays of lead, that with tin is moſt uſed, being employed for ſoldering by plumbers, and for tinning. If an allay of lead and tin be expoſed to an open fire, ſufficiently ſtrong to make the metal red-hot and to ſmoke, theſe two metals will burn and calcine together much more quickly and perfectly than either of them would do ſingly. The calx reſulting from this operation is the baſis of white enamels, and glazings for earthen ware. It is called *putty*.

The affinities of lead, according to Mr. Geoffroy's table, are ſilver and copper: according to Mr. Gellert's table, they are ſilver, gold, tin, copper. Iron is marked in this table as being incapable of uniting with lead.

Lead and its ſeveral preparations are of great uſe. It is uſed and formed into ſheets and pipes, for containing and conducting water in buildings and gardens. Lead is not much uſed in medicine, only externally, from the colics and palſies which it occaſions when taken internally. But its external applications are very uſeful, from its ſedative, drying, and repelling qualities. The vinegar and the ſugar of lead, alſo all the ointments and plaſters which contain ceruſs, minium, or litharge, eminently poſſeſs theſe qualities. We have ſeen that lead is much employed in painting with oil, both as a color and as a dryer. It is alſo uſed in the preparation of enamels and of porcelain as a flux, and makes the baſis of the glazing of almoſt all pottery wares from the moſt ordinary kind to the fineſt. Laſtly, by means of lead, the moſt perfect metals are refined and eſſayed. We may therefore ſay, that this metal is ſo generally uſed, and ſo neceſſary in the important arts we have mentioned, that they abſolutely could not exiſt without it.

CCCCXI. LEATHER (FOSSIL). (g)

CCCCXII. LEAVES. (h)

(g) Leather (Fossil). *Aluta montana*. This is a foliated amianthus, conſiſting of ſoft fibres interwoven together. Frequently it contains ſparry cryſtals encloſed in it. For the properties of this ſtone, *ſee* Amianthus.

(h) Leaves. The following remarks concerning the coloring ſubſtance of leaves are taken from Dr. Lewis. The green color of the leaves of plants may be extracted by rectified ſpirit of wine and by oils. The ſpirituous tinctures are generally of a fine deep green, even when the leaves themſelves are dull colored, or yellowiſh, or hoary. The color however ſeldom remains long in theſe liquors; and it remains a much ſhorter time when the coloring matter is ſeparated in a ſolid form, and expoſed to air. The [illegible] gives a more durable green color to ſpirit than any other herb. Alkalis heighten the colors of the tinctures and of the juices; and acids weaken, deſtroy, or change them to a brown color. Lime-water improves the color, and alſo the durability of the color. By means of lime, not inelegant green lakes may be obtained from the leaves of [illegible], *lily of the valley*, and of ſeveral other plants. Few herbs communicate any part of their green color to water; perhaps none give a green conſiderably deep. Nevertheleſs a green dye is ſaid to be given to woolen by the leaves of ſome plants, as of the wild *chervil*, or *cow-weed*, the common *rag-wort*, and *devil's-bit*. The leaves of many kinds of herbs and trees give a yellow dye to wool, previouſly boiled in a ſolution of alum and tartar. *Weld* particularly affords a fine yellow dye. Mr. Hellot obſerves, that all leaves, barks, and roots, which have an aſtringent taſte, as the leaves of the *almond*, *peach*, and *pear* trees, aſh-bark, roots of *wild patience*, &c. yield durable yellows. From the leaves of two plants, *blue* coloring ſubſtances are produced, namely, *indigo* and *woad*; which *ſee*. Mr. Hellot ſuſpects that a ſimilar blue fecula might be produced from many other vegetables. He ſuppoſes the green color of vegetables to proceed from a mixture of blue and yellow particles, and that the former are frequently more permanent than the latter, ſo as to be capable of reſiſting the fermentation of the juice of the plants, while the yellow are deſtroyed by that fermentation. Dr. Lewis has tryed, without ſucceſs, to obtain blue dyes from other plants, by putrefying them in water.

CCCCXIII. **LEY (CAUSTIC),** *or the* **LEY** *of* **SOAP-BOILERS.** This name is given to lixiviums of fixed alkali rendered cauſtic by quicklime. To make theſe leys, two parts of ſoda or of potaſh are mixed with one part of quicklime; or equal parts of alkaline ſalt ready prepared and quicklime are added together. This mixture is to be put into a large veſſel, and 12 or 15 times as much pure water is to be poured upon it, and the quicklime is to be thus ſlaked: after which the whole is to be boiled during ſome minutes, and the ley while yet hot is to be filtered through a brown paper filter ſupported upon linen, and the ley is to be concentrated by evaporation upon the fire, to ſuch a degree as is judged neceſſary, according to the uſe for which it is deſigned.

Quicklime has the property of encreaſing conſiderably the cauſticity of all fixed alkalis; and this is probably done, not only by taking from them their ſuperabundant inflammable matter, but a part alſo of that which enters into their compoſition as a principle. Hence a conſiderable alteration is produced upon theſe alkalis by quicklime, ſimilar to that produced upon volatile alkali, and we may conſequently decompoſe entirely all alkalis by quicklime. But theſe experiments have not been hitherto proſecuted. The properties of fixed alkali rendered cauſtic have not been ſufficiently examined. We know only that by this treatment the diſſolving power of alkalis, and particularly upon oily matters, is much encreaſed; and they are therefore thus prepared, when they are to be combined with oils for the formation of ſoaps. (*i*)

The cauſtic ley, evaporated to dryneſs, furniſhes an alkaline ſalt exceedingly acrid, which being melted in a crucible becomes what is called *common cauſtic*; becauſe when it is applied to the ſkin, it makes an eſchar, pierces it, and leaves an ulcer, the ſuppuration of which, when continued, is called an *iſſue*.

Cauſtic alkali has not only much greater diſſolving power, but it is alſo much more deliqueſcent, and attracts much more powerfully the moiſture of the air, than ordinary alkali. Theſe properties muſt proceed from the developement of the ſaline principle by the quicklime. *See* ALKALI.

CCCCXIV. **LILLY** *of* **PARACELSUS.** *See* **TINCTURE** *of* **METALS.**

CCCCXV. **LINNEN (FOSSIL.)** (*k*)

CCCCXVI. **LIQUOR SILICUM.** LIQUOR *of* FLINTS. The preparation of this liquor conſiſts in uniting by fuſion powdered flints or ſand with a ſufficient quantity of fixed alkali, ſo that a compound reſults from it in which the properties of the alkali prevail, and particularly a total ſolubility in water. For this purpoſe one part of ground flints or ſand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated.

When this mixture has acquired a certain heat, a conſiderable boiling and ſwelling are obſervable, occaſioned by the action of theſe two matters upon

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(*i*) The effect produced upon alkalis by quicklime is the abſorption of their fixable air. *See* AIR (FIXABLE) *and* ALKALI.

(*k*) LINNEN (FOSSIL). Is a kind of *amianthus* which conſiſts of flexible, parallel, ſoft fibres, and which has been celebrated for the uſe it has been applied to, of being woven, and forming an *incombuſtible cloth*. Paper has alſo been made of it, and wicks for lamps. *See* AMIANTHUS.

each other. To prevent the matter in this ſtate from flowing over the crucible, this ought to be large, and the fire gradually raiſed. A part only of the mixture may be put into the crucible at once; and when its efferveſcence is over, the reſt may be added at different times, taking care that each portion to be added be previouſly heated, to prevent exploſion from any moiſture which it might contain, when mixed with red-hot melted matter.

When the efferveſcence of all the mixture is over, it is to be kept in a good fuſion during a quarter of an hour, and is then to be poured upon a greaſed ſtone or plate of iron. The matter when cold is brittle, and ſeems vitrified. It is even tranſparent like glaſs, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and ſtrongly attracts moiſture from the air, and is entirely ſoluble in water, except a very ſmall portion of earthy matter. But a ſimilar earth is alſo always ſeparated from pure fixed alkali during its ſolution in water.

The filtrated ſolution is at firſt clear, and limpid; but it afterwards becomes turbid, and forms an earthy ſediment, like that formed by ſolutions of fixed alkali, only the former ſeems more copious. This liquor has all the properties of liquid fixed alkali.

All theſe properties of alkaline ſalts, and particularly its total ſolubility in water, are cauſed by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the compoſition of any body do alſo predominate in that body, we may perceive why the properties of the fixed alkali in the preſent combination ſhould be more ſenſible than thoſe of the earthy matter or flints. The alkali communicates to the earthy matter ſome of its ſtrong diſpoſition to unite with water. The flints are really kept diſſolved in water, and by this experiment they are conſequently reduced into a liquor, and hence it has been called the *liquor of flints.* If any acid be added to the liquor of flints ſo as to ſaturate the alkali, the flint which was kept diſſolved in water by means of this alkali will be now precipitated in ſtate of a fine earth. Mr. Pott mentions a very ſingular phenomenon which happens in this experiment, which is, that this earthy precipitate is entirely ſoluble by acids; ſo that if more acid be added than is ſufficient to ſaturate the alkali, the precipitate will entirely diſappear.

As vitrifiable earths in their natural ſtate, and even when divided as much as is poſſible by mechanical methods, are inſoluble in acids, and as they become ſoluble by acids, when they have been combined by fuſion with a ſufficient quantity of fixed alkali, they muſt conſequently undergo a ſingular alteration in this operation. This property which they acquire of diſſolving in acids, proceeds either from the great fineneſs to which their parts are reduced, or from a ſmall portion of fixed alkali, or from ſome of its principles which remain united with them, and from which they cannot be entirely ſeparated by the precipitating acid.

The fixed alkali which enters into this combination receives alſo ſome alteration from the vitrifiable earth; one part of it is decompoſed, and its earth is precipitated with the vitrifiable earth, and the remaining part is rendered much more cauſtic than it was before.

In all vitrifications ſomething happens ſimilar to what is obſerved in the compound deſigned to make the liquor of flints. The glaſſes which contain too much alkaline ſalt in their compoſition, or which have not ſuſtained a long or ſtrong enough fire to unite the earth intimately with the fixed alkali, are partly ſoluble in acids, have ſometimes even an alkaline taſte, tarniſh, and moiſten in the air. *See* VITRIFICATION.

CCCCXVI. LIQUOR, *or* SPIRIT (SMOKING) *of* LIBAVIUS. This preparation is a marine acid very concentrated, ſmoking, and impregnated with much tin. It is obtained by diſtillation from a mixture of corroſive ſublimate with tin.

To make the ſmoking liquor of Libavius, an amalgam muſt be made of four parts of tin and five parts of mercury: this amalgam is to be well mixed with an equal weight of corroſive ſublimate, by triturating the whole together in a glaſs mortar. This mixture is to be put into a glaſs retort, which is to be placed in a reverberatory furnace. To the retort is to be luted with fat lute a receiver with a ſmall hole in it, in the ſame manner as is done for the diſtillation of concentrated mineral acids. The diſtillation is then to be begun with a graduated and well managed fire. A very ſmoking liquor paſſes into the receiver, and towards the end of the diſtillation a very thick and even concrete matter. When the operation is finiſhed, the liquor in the receiver is to be poured quickly into a cryſtal glaſs bottle with a glaſs ſtopper. When this bottle is opened, a white, copious, thick, and poignant fume iſſues, which remains long in the air without diſappearing.

The very concentrated marine acid contained in the corroſive ſublimate quits the mercury in this experiment to unite with the tin; and as this acid has the property of raiſing with it in diſtillation moſt metallic matters, a conſiderable quantity of the tin paſſes over in this diſtillation. Nevertheleſs this acid is far from being ſaturated with tin; it is ſtill very acid, and capable of diſſolving much tin in the ordinary way. From this imperfect ſaturation, together with its great concentration, proceeds partly its property of ſmoking ſo conſiderably. Nevertheleſs ſome other cauſe probably concurs to give it this property. For although this liquor ſmokes infinitely more than the moſt concentrated ſpirit of ſalt, diſtilled in Glauber's manner, its vapors are notwithſtanding much leſs elaſtic. Another very eſſencial difference betwixt this liquor and concentrated ſpirit of ſalt is, that by mixing the former, but not the latter, with ſpirit of wine, marine ether may be obtained. *See* ETHER (MARINE).

Laſtly, if we attempt to diſſolve, by the ordinary method, as much tin in concentrated ſpirit of ſalt as is contained in the ſmoking liquor of Libavius, this acid, ſo far from being thereby rendered more ſmoking, ceaſes entirely to ſmoke. A real difference therefore ſubſiſts betwixt the marine acid impregnated with tin by the decompoſition of corroſive ſublimate, and by diſtillation, and the marine acid treated with tin in any other manner. But we cannot eaſily determine whence this difference proceeds. Does this acid depoſit in the mercury or in the tin ſome of its principles? If that be the caſe, with what principle is tin impregnated in this experiment? Is it with phlogiſton? or with mercurial earth? Theſe queſtions cannot be decided without further reſearches.

The ſmoking liquor has all the other properties of the moſt concentrated marine acid, when imperfectly ſaturated with tin. If it be diluted with much water, moſt of its tin will be ſeparated from it in the form of white light flakes.

when it is mixed with a ſolution of gold in aqua regia, it forms the purple precipitate of Caſſius, as all other ſolutions of tin, and even pure tin not diſſolved, do. *See* PRECIPITATE (PURPLE) *of* CASSIUS. It may be precipitated by abſorbent earths, and by alkaline ſalts. In ſeveral dyes, particularly in thoſe which are red, it produces the ſame effects as tin diſſolved by marine acid. *See* DYEING.

The neceſſary management for making the ſmoking ſpirit of Libavius is not very troubleſome or difficult. This operation is much eaſier than the diſtillation of very ſmoking ſpirit of ſalt by means of vitriolic acid, from the greater elaſticity and expanſive force of the vapors of the latter.

For the diſtillation of the ſmoking ſpirit of Libavius, the tin is previouſly amalgamated with mercury, becauſe in this ſtate it is much more eaſily miſcible with corroſive ſublimate. If the diſtillation be continued, and the heat encreaſed, after the butter of tin, or the concrete part of the combination of tin with marine acid, has riſen, the mercury revived from the corroſive ſublimate may be obtained. *See* ACID (MARINE), TIN, MERCURY, *and* CORROSIVE SUBLIMATE.

CCCCXVII. **LIQUOR (MINERAL ANODYNE) *of* HOFFMAN.** This compoſition, which is uſed in medicine only, is a mixture of very rectified ſpirit of wine, of ether, and of a little of the ſweet oil of vitriol. This liquor is made by mixing an ounce of the ſpirit of wine which riſes firſt in the diſtillation of ether, with as much of the liquor, and afterwards by diſſolving in this mixture, which riſes next, and which contains the ether, twelve drops of the oil which riſes after the ether has paſſed. This is what is called the mineral anodyne liquor of Hoffman. It has preciſely the ſame virtues as the ether, which phyſicians now begin to ſubſtitute for it. As ether and oil of ſpirit of wine is now made from the nitrous, marine, and acetous acids, liquors may be made from theſe, in imitation of that of Hoffman from the vitriolic acid. *See* ETHERS.

CCCCXVIII. **LITHARGE.** Litharge is lead deprived of great part of its phlogiſton by fire, and is in a ſtate of imperfect vitrification.

When ſilver is refined by cupellation with lead, this latter metal, which is ſcorified, and cauſes the ſcorification of the imperfect metals allayed with the ſilver, is transformed into a matter compoſed of ſmall ſemi-tranſparent ſhining plates, reſembling mica; which is litharge. Litharge is more or leſs white or red, according to the metals with which the ſilver was allayed. The white is called *litharge of ſilver*, and the red is called *litharge of gold*.

Litharge may be eaſily revived into lead; accordingly much of that which is produced by refining in great is reduced, by being melted upon burning coals. The part of it which is leaſt altered by mixture with other metals is thus reduced, and by this method good and ſaleable lead is obtained. The reſt of the litharge of theſe refineries is ſold and uſed for various purp [illegible] Potters uſe much of it for glazing their ware. It is employed for the [illegible]tion of ſome plaſters, and other external remedies; and alſo in painting [illegible]der linſeed oil drying. Laſtly, it is added in the compoſition of [illegible] glaſſes, for it is very fuſible, and aſſiſts the fuſion of other ſubſtances. It has in general the ſame properties as the other calxes of lead. All the litharge which is commonly ſold comes from refineries. The quantity formed there is more than is ſufficient for the demand, and therefore it is not prepared purpoſely. *See* Refining *and* Lead.

CCCCXIX. LIVER *of* ANTIMONY. Liver of antimony reſults from the detonation of antimony with an equal weight of nitre. Theſe two matters reduced into powder are to be mixed together, and put into a large crucible. The matter is then to be kindled, and the detonation to be made. When it has detonated, it is to be kept in fuſion and then cooled. When the crucible is broken, at the bottom two diſtinct matters are found, which may be ſeparated from each other by the ſtroke of a hammer. The upper matter is a ſaline ſcoria, nearly of the ſame nature as the ſcoria of the regulus of antimony. This is a true antimoniated liver of ſulphur, mixed with a certain quantity of vitriolated tartar. The lower matter is heavier. It is opake, compact, red, and brittle. This is the liver of antimony. Its color and appearance have been ſuppoſed ſimilar to thoſe of the livers of animals, and thence it has received its name.

Liver of antimony is principally compoſed of the metallic part of antimony, half deprived of its ſulphur, and dephlogiſticated by nitre.

Some chemiſts conſider the liver of antimony as an antimoniated liver of ſulphur. Others affirm, that it is only the metallic earth of antimony, melted, by means of a remaining part of ſulphur and phlogiſton, into a ſubſtance the nature of which is intermediate betwixt thoſe of antimony and of glaſs of antimony. It may poſſibly be ſometimes in one ſtate, and ſometimes in the other, according as the matter has been more or leſs long in the fire, and more or leſs well fuſed. The true nature of this ſubſtance may eaſily be aſcertained by a proper examination. But this preparation, which was conſidered as important when antimonial remedies were firſt introduced, deſerves at preſent little notice. For it is not of any uſe in what is properly called Chemiſtry; and it is no longer employed in Medicine, ſince kermes mineral and emetic tartar have been introduced, which are remedies ſuperior to all other antimonials from the certainty of their effects, when they are well prepared, and by which all the effects obtainable by any preparation of antimony may be obtained, by giving them ſeparately or conjunctly in different proportions, according to the indications to be anſwered. *See* Antimony, Kermes Mineral, *and* Tartar (Emetic).

CCCCXX. LIVER *of* ARSENIC. Liver of arſenic is a combination of white arſenic with liquid fixed vegetable alkali, or by the humid way. Arſenic has in general a ſtrong diſpoſition to unite with alkalis. Mr. Macquer, in his Memoirs upon Arſenic, mentions a ſingular kind of neutral ſalt, which reſults from the union of arſenic with the alkaline baſis of nitre, when nitre is decompoſed, and its acid is diſengaged in cloſe veſſels, by means of arſenic. To this ſalt he has given the name of *neutral arſenical ſalt.* See that article. The liver of arſenic mentioned alſo by that chemiſt, although compoſed, like the neu[illegible]ſenical ſalt, of arſenic and fixed alkali, is nevertheleſs very different from th[illegible].

The operation for making liver of arſenic is eaſy and ſimple. To ſtrong and concentrated liquid fixed alkali, previouſly heated, fine powder of white arſenic muſt be added. This arſenic eaſily diſappears and diſſolves, and as much of it is to be added till the alkali is ſaturated, or has loſt its alkaline properties, although it is ſtill capable of diſſolving more arſenic ſuperabundantly. While the alkali diſſolves the arſenic in this operation, it acquires a browniſh color, and a ſingular and diſagreeable ſmell, which however is not the ſmell of pure arſenic heated and volatiliſed. Laſtly, this mixture becomes more and more thick, and at length of a gluey conſiſtence. This matter is not cryſtallizable as the neutral arſenical ſalt is. It is eaſily decompoſed by the action of fire, which ſeparates the arſenic. This does not happen to the arſenical ſalt. Laſtly, any pure acid is capable of ſeparating arſenic from the liver of arſenic, in the ſame manner as they ſeparate ſulphur from liver of ſulphur: whereas the neutral arſenical ſalt cannot be decompoſed but by means of the united affinities of acids and metallic ſubſtances. Thus we ſee that arſenic may be combined with fixed alkali in two very different manners.

The author has given to this combination the name of *liver of arſenic*, to diſtinguiſh it from the neutral arſenical ſalt, and in imitation of the name of the *liver of ſulphur*, given to the combination of the fixed alkali with ſulphur. *See* ARSENIC *and* NEUTRAL ARSENICAL SALT.

CCCCXXI. LIVER *of* SULPHUR. The liver of ſulphur is the combination of ſulphur with alkaline matters. Ordinary liver of ſulphur, or the combination of ſulphur with fixed alkali, may be made either in the dry or humid way.

To make liver of ſulphur by the dry way, or by fuſion, equal parts of fixed alkali and ſulphur are mixed together. This mixture is to be put into a crucible, and it is to be quickly fuſed to avoid the diſſipation and combuſtion of the ſulphur. A ſtrong heat, however, is not neceſſary; becauſe the ſulphur eaſily melts and facilitates the fuſion of the alkali. When this mixture is perfectly fuſed, it is to be poured upon a greaſed ſtone, and then the liver of ſulphur congeals and acquires a brown color. If it be required to be kept dry, it muſt be quickly broken in pieces, and put while it is yet hot into a bottle which is to be well corked, becauſe it readily imbibes moiſture from the air.

To make liver of ſulphur in the humid way, concentrated liquid fixed alkali and fine powder of ſulphur are to be boiled together, till the alkali has diſſolved all that it can: the liquor is then to be filtrated and evaporated. This ſecond method of making liver of ſulphur is not much uſed, becauſe it is longer and leſs advantageous than the former.

Liver of ſulphur is an important combination in chemiſtry, becauſe it is in general a very powerful ſolvent. This compound partakes, according to the general rule, of the properties of the two ſubſtances which enter into its combination. The ſulphur, by its union with the alkali, appears leſs volatile, leſs combuſtible than when alone, and may be entirely diſſolved in water by the intervention of this alkali; and alſo this alkali, ſaturated with ſulphur, ſhews leſs of its alkaline properties.

As ſulphur is compoſed of vitriolic acid and phlogiſton, we may doubt to which of theſe its union with the fixed alkali is to be attributed. But if we attend to the properties of liver of ſulphur, we ſhall perceive that the ſulphur is in all its ſubſtance combined with the alkali, and adheres to it by both its principles. In fact, if we diſſolve liver of ſulphur in water, and pour into this ſolution any acid, the liver of ſulphur will be inſtantly decompoſed by this acid, which will unite with the alkali, and ſeparate from it the ſulphur in form of a white powder: but this powder, when dried and examined, appears to be ſulphur, ſuch as it was before.

Although vitriolic acid which is contained in ſulphur be in general the ſtrongeſt acid, the ſulphur is nevertheleſs ſeparated from the alkali by any acid, even by the weakeſt, as vinegar. This phenomenon is another proof of what we have advanced concerning the manner in which ſulphur is combined with alkali; for if the union of the inflammable principle of the ſulphur did not conſiderably oppoſe the adheſion which the acid of this ſulphur is capable of contracting with fixed alkali, the weaker acids certainly could not ſeparate it. Theſe effects may be explained by this general principle, that the leſs ſimple any bodies are, the leſs ſtrongly they are capable of adhering to other bodies.

The liver of ſulphur exhibits alſo another phenomenon worthy of attention, and which depends alſo, as we ſhall ſee, on the ſame principle. It is, that the connexion betwixt the phlogiſton and the acid is much leſs in ſulphur united to an alkali than in pure ſulphur. This is proved by the ſmell of the liver of ſulphur, which is very ſtrong and very fetid, even when it is not heated; while ſulphur, not heated, has ſcarcely any ſmell.

This ſmell of the liver of ſulphur, which reſembles much the ſmell of eggs beginning to putrify, becomes much ſtronger when it is decompoſed by an acid. It is certainly occaſioned by an evaporation of part of the phlogiſton of the ſulphur; for it produces exactly all the effects of the inflammable principle when reduced into vapor, or when it diſengages itſelf from bodies without burning. It particularly affects the brain and nervous ſyſtem, and cauſes ſtupefaction, intoxication, ſyncopes, and when in large quantity is even capable of inſtantly killing men and animals. Theſe are the ſame effects which are produced by the vapors of charcoal, and of ſubſtances undergoing the ſpirituous or putrid fermentations. Mr. Cartheuſer, talking of the manner of decompoſing ſulphur with an alkali, to obtain from it the acid without ſenſible combuſtion, according to Stahl's proceſs, expreſsly remarks, that the vapor which exhales during this operation affects the head, and cauſes ſtupefaction. I know a chemiſt who, when he was decompoſing at once a large quantity of liver of ſulphur by an acid, was ſtruck by the vapor ſo as to fall down and faint.

Further, the emanations of liver of ſulphur, which are nothing elſe than pure phlogiſton reduced into vapor, and which muſt be diſtinguiſhed from the vapor of burning ſulphur, which are phlogiſticated vitriolic acid; theſe emanations, I ſay, of liver of ſulphur are eaſily applied to any body capable of receiving the inflammable principle, and combine more or leſs intimately with theſe bodies, according to their nature and actual ſtate. If ſilver, for example, be expoſed to the vapor of liver of ſulphur, or if it be immerſed in a heated ſolution of liver of ſulphur, the ſurface of this metal becomes tarniſhed and blackened by the phlogiſtic emanations, with which it readily is impregnated ſuperabundantly. Alſo, if ſolutions of ſilver, mercury, lead, or biſmuth, be precipitated by liver of ſulphur, all theſe precipitates, inſtead of being white, as they would have been if a pure alkali had been uſed, are rendered brown, black, or leaden-colored, by the phlogiſton which attaches itſelf to them: hence ſolutions of theſe metals become ſympathetic inks, which may be rendered viſible by liver of ſulphur, or by its vapor; and hence liver of ſulphur may be ſucceſsfully employed to diſcover lead contained in adulterated wine; and reciprocally, theſe metals, their ſolutions or calxes, may be properly applied to diſcover ſulphur in mineral waters or other liquors. *See* INK (SYMPATHETIC), WATERS (MINERAL), *and* WINE.

We muſt obſerve, that in this application of the phlogiſton of liver of ſulphur to moſt metallic calxes, this phlogiſton, although tranſmitted either in vapor, or by the humid way without fuſion, combines nevertheleſs ſo intimately with theſe metallic earths as to revive them, and to reſtore to them all their metallic properties. This truth, though long ago known to chemiſts, was alluded to by Mr. Rouelle the younger, who, in the Medical Gazette, propoſes this reduction in form of a problem, as a very great novelty. The chemiſt who replied, judiciouſly uſed litharge to make this reduction viſible; becauſe this preparation of lead being in molecules or ſcales, which preſent ſurfaces very ſmooth and ſufficiently large, is very proper to ſhew the metallic color and brilliancy which the litharge inſtantly aſſumes, when it is immerſed even in a cold ſolution of liver of ſulphur. *See* REDUCTION.

All theſe properties of liver of ſulphur ſhew very clearly, that the adheſion of the phlogiſton to the acid in ſulphur is greatly diminiſhed by the union of ſulphur with alkali; and as the phlogiſton is infinitely more volatile than the acid, it may therefore be more eaſily ſeparated from the liver of ſulphur. The ſmell and emanations of liver of ſulphur ſhew, that its inflammable principle is continually diſſipating. We may therefore conſider ſulphur, formed into liver of ſulphur, as gradually decompoſing, particularly when it is diſſolved in water. Accordingly, if we preſerve liquid liver of ſulphur in an open veſſel, the quantity of ſulphur diminiſhes more and more, and the liver of ſulphur gradually changes into vitriolated tartar.

We may form an explanation of this diminution of the connexion of the principles of ſulphur in the liver of ſulphur, if we ſuppoſe that all bodies have only a certain determinate degree of force by which they adhere to each other; which is very probable, and is even ſhewn by all the phenomena of chemiſtry; and if we ſuppoſe, in the ſecond place, that in ſulphur the phlogiſton and acid have exhauſted upon each other all their force of tendency or of combination. Upon theſe ſuppoſitions, theſe two principles are either incapable of combining with a third body, as with the alkali; or if they combine with it, this new union muſt leſſen the force of the former union; and this accordingly appears to be the reaſon why the ſimpleſt bodies are thoſe which contract the ſtrongeſt union. *See* AFFINITY, AGGREGATION, COMBINATION, *and* SOLUTION.

Liver of ſulphur is a great ſolvent of metallic matters; all which, excepting zinc, it attacks, particularly in fuſion. It ſeems to diſſolve gold more effectually than other metals. *See* GOLD. This compound diſſolves alſo vegetable coals, even by the humid way, according to the obſervation of Mr. Rouelle the younger. This ſolution is of a green color; and when liver of ſulphur has diſſolved charcoal by fuſion, it becomes of a much deeper red color than when pure, as may be obſerved in the making of artificial ſulphur in Stahl's manner.

Particular kinds of liver of ſulphur may be formed by the combination of volatile alkali, of quicklime, or of abſorbent earths, all which attack ſulphur more or leſs. The properties of theſe livers of ſulphur may be referred to thoſe of the ordinary one; but they have not been examined ſo much as they ought to be. *See* SULPHUR.

CCCCXXII. **LIXIVIAL.** Thoſe ſalts are called lixivial which have been extracted by lixiviation, and theſe chiefly are fixed alkalis; which are therefore called *lixivial ſalts*. *See* ALKALI.

CCCCXXIII. **LUNA CORNEA.** This name is given to the combination of marine acid with ſilver. Marine acid has in general a great affinity with metals, and particularly with thoſe called *white*, or *lunar*, or *mercurial metals*. Of theſe ſilver is the chief. Marine acid can ſcarcely diſſolve theſe metals in the ordinary methods. They muſt be generally much divided, or the acid muſt be much concentrated, reduced into vapors, and aſſiſted with a conſiderable degree of heat, to accompliſh the ſolution. This is particularly true as to ſilver and mercury. But when theſe metals are previouſly diſſolved in nitrous acid, then the marine acid, which has a ſtronger affinity with them than the nitrous has, ſeizes them quickly, ſeparates them from the nitrous acid, and forms with them a new combination.

To make this combination with ſilver, it is firſt diſſolved in nitrous acid. To this ſolution marine acid, or more commonly common ſalt diſſolved in water, is to be added. The mixture ſoon becomes turbid, and in it a copious precipitate is formed, which has always the appearance of curd. The ſolution of ſalt is thus added till no more precipitate is formed. The precipitate, when ſeparated from the ſupernatant liquor, is called *luna cornea*.

Marine acid has ſo great an affinity with ſilver, that it overcharges itſelf in ſome meaſure with the metal in this precipitation. Luna cornea is much leſs ſoluble in water than the combinations of other metals with this acid. This little ſolubility of luna cornea is the cauſe of its appearing in the form of a precipitate.

The adheſion of the marine acid with ſilver is very ſtrong in luna cornea. If this matter be expoſed alone to fire, the acid carries off with it a portion of the ſilver, although this metal be very fixed. The remaining matter melts, and takes the form of a horn-like ſubſtance, as all chemiſts ſay; and hence it has been called luna cornea. Some differences muſt occur in combining marine acid with ſilver, according to the manner in which it is done, and particularly according to the proportion of the two ſubſtances.

Luna cornea is not employed either in medicine or in the arts *(l)*; and is even little uſed in chemiſtry, excepting for particular operations and reſearches. This precipitation is very convenient, for example, in the examination of mineral waters, or of any other liquor, to diſcover if they contain marine acid in whatever baſe it be engaged, excepting metallic baſes; for if theſe waters contain the ſmalleſt quantity of marine acid, a luna cornea will be precipitated by

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(*l*) Luna cornea mixed with ſea-ſalt and tartar rubbed on braſs, gives a ſilver-like appearance; and is the ſubſtance employed for the ſilvering of the dial-plates for clocks. A more ſubſtantial ſilvering may be given by the above mixture, if the piece of braſs to be ſilvered be previouſly heated conſiderably, and cleaned with a ſcratch-bruſh, and if the operation be repeated till the ſilver ſeems to be ſufficiently thick. The braſs, having a ſtronger diſpoſition to unite with the marine acid than the ſilver has, ſeparates it from this latter metal, which is then precipitated upon the ſurface of the braſs plate.

them from a ſolution of ſilver in nitrous acid, and this luna cornea is eaſily known by its curd-like appearance. *See* WATERS (MINERAL).

We may eaſily perceive that when the marine acid, which forms the luna cornea, is engaged in a baſis, it muſt quit its baſis to combine with the ſilver; and then the nitrous acid, which was united with the ſilver, is now diſengaged, and joins itſelf to the ſubſtance with which the marine acid was firſt united; ſo that two decompoſitions take place, from which two combinations reſult. Thus, when luna cornea is made with a ſolution of common ſalt, the liquor after the operation contains ſome cubic nitre; and if marine ſalt with an earthy baſis was uſed, it would be transformed, in this operation, into a nitre with an earthy baſis.

The beſt method of ſeparating ſilver from marine acid, or, as the chemiſts ſay, of reducing luna cornea, is to mix it very accurately, and to melt it in a crucible, with a very large quantity of ſome fixed alkali: but the heat muſt be very gradually applied till the ebullition and ſwelling, which are cauſed by the action of the fixed alkali and marine acid, have ceaſed; then the heat is to be encreaſed, and the matter is to be thoroughly fuſed; after which, the ſilver is found revived at the bottom of the crucible. This ſilver is juſtly eſteemed to be the pureſt of all, when the ſeveral operations have been well made. But the luna cornea cannot eaſily be reduced without loſs; becauſe it is apt to evaporate partly, and even to paſs through crucibles. *See* ACID (MARINE), *and* SILVER *.

CCCCXXIV. **LUTE.** In many chemical operations, the veſſels muſt be covered with ſomething to preſerve them from the violence of the fire, from being broken or melted, and alſo to cloſe exactly their joinings to each other, to retain the ſubſtances which they contain, when they are volatile and reduced to vapor. For this purpoſe, ſeveral matters are employed, called in general *lutes*.

The lutes with which glaſs and earthen-ware retorts are covered ought to be compoſed of nearly equal parts of coarſe ſand and refractory clay. Theſe matters are to be well mixed with water and a little hair, ſo as to form a liquid paſte, with which veſſels are to be covered, layer upon layer, till it is of the required thickneſs.

The ſand mixed with the clay is neceſſary in this lute, to prevent the cracks which are occaſioned by the contracting of clay during its drying, which it always does when it is pure. The hair ſerves alſo to bind the parts of the lute, and to keep it applied to the veſſel: for, notwithſtanding the ſand which is introduced into it, ſome cracks are always formed, which occaſion pieces of it to tumble off.

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* Mr. Margraaf has made experiments to diſcover the beſt method of reducing luna cornea, which he found to be the following: Diſſolve half an ounce of fine ſilver in aqua fortis, precipitate it by ſea-ſalt, and edulcorate the precipitate, which will then weigh five drams and ſixteen grains. For the reduction of this precipitate, mix it with an ounce and a half of dry volatile ſal ammoniac, triturate them well together with a little water during a quarter of an hour; then add three ounces of mercury obtained from cinnabar by means of quicklime, and continue to triturate during ſome hours with a little more water. Thus an amalgam will be formed, which being waſhed from a white powder and dried, will weigh three ounces and half a dram. By diſtillation of this amalgam, a reſiduum of ſilver, four grains leſs than the original half-ounce, will be obtained. By ſubliming the white powder, which weighs five drams, three grains of ſilver will be obtained: but if the amalgam and white powder be together diſtilled, the operation will fail, and the luna cornea be recompoſed. *See* BERLIN MEMOIRS, 1749.

The lutes with which the joinings of veſſel are cloſed, are of different kinds, according to the nature of the operations to be made, and of the ſubſtances to be diſtilled in theſe veſſels.

When vapors of watery liquors, and ſuch as are not corroſive, are to be contained, it is ſufficient to ſurround the joining of the receiver to the noſe of the alembic, or of the retort, with ſlips of paper or of linen, covered with flour-paſte. In ſuch caſes alſo ſlips of wet bladder are very conveniently uſed.

When more penetrating and diſſolving vapors are to be contained, a lute is to be employed of quicklime ſlaked in the air, and beat into a liquid paſte with whites of eggs. This paſte is to be ſpread upon linen ſlips, which is to be applied exactly to the joining of the veſſels. This lute is very convenient, eaſily dries, becomes ſolid, and ſufficiently firm.

Laſtly, when ſaline, acid, and corroſive vapors are to be contained, we muſt then have recourſe to the lute called *fat lute*. This lute is made by forming into a paſte ſome dried clay, finely powdered, ſifted through a ſilken ſearce, and moiſtened with water, and then by beating this paſte well in a mortar with boiled linſeed oil, that is, oil which has been rendered drying by litharge diſſolved in it, and fit for the uſe of painters. This lute eaſily takes and retains the form given to it. It is generally rolled into cylinders of a convenient ſize. Theſe are to be applied, by flattening them, to the joinings of the veſſels, which ought to be perfectly dry, becauſe the leaſt moiſture would prevent the lute from adhering. When the joinings are well cloſed with this fat lute, the whole is to be covered with ſlips of linen ſpread with lute of lime and whites of eggs. Theſe ſlips are to be faſtened with pack-thread. The ſecond lute is neceſſary to keep on the fat lute, becauſe this latter remains ſoft, and does not become ſolid enough to ſtick on alone.

M.

CCCCXXV. MACERATION. Maceration is the ſteeping of bodies in a cold liquor, to ſoften, penetrate, and open them; or even to diſſolve ſome principle of them. This operation is eſſentially the ſame as digeſtion, and only differs in this, that it requires no more than the heat of the atmoſphere. Maceration is preferable to digeſtion, whenever heat is uſeleſs or hurtful to the operation. For inſtance, when hard and woody aromatic vegetable matters are to be ſteeped, with intention to ſoften and open them, to extract afterwards more eaſily from them their eſſential oil, they ought to be macerated without heat, and not digeſted, conſidering that the ſmalleſt heat is capable of diſſipating a great part of the ſpiritus rector, which ought always to be preſerved as much as is poſſible, ſince it ameliorates the eſſential oil, and encreaſes its quantity.

CCCCXXVI. MADDER. *(m)*

CCCCXXVII. MAGISTERY. This name is given to almoſt all precipitates. Thus magiſtery and precipitate are frequently ſynonimous: but lately chemiſts have chiefly uſed the term precipitate, and applied that of magiſtery to ſome particular precipitates only, which are uſed in medicine and in the arts. Such are the magiſteries of biſmuth, coral, crabs-eyes, ſulphur, &c. *See* PRECIPITATION *and* PRECIPITATE.

CCCCXXVIII. MAGISTERY *of* BISMUTH. The magiſtery of biſmuth is the calx of that ſemi-metal, ſeparated from the nitrous acid by water alone, and well waſhed.

To make this preparation, very pure biſmuth muſt be diſſolved in nitrous acid, which muſt alſo be very pure. To this ſolution when a very large quantity of clear water is added, the whole is rendered turbid and milky, and a

(m) MADDER. The root of madder impregnates water with a dull red color, and ſpirit of wine with a deep bright red. This root, when eat by animals along with their food, tinges their urine, and their moſt ſolid bones, of a deep red. Wool, previouſly boiled in a ſolution of alum and tartar, receives from a hot decoction of madder and tartar a very durable, but not a very beautiful red color.

very beautiful and ſhining white ſediment is afterwards formed. The ſupernatant liquor is then to be decanted; the ſediment is to be put upon a paper filter, and more pure water is to be added, till it comes off quite inſipid. The ſediment, which is the magiſtery of biſmuth, ought to be carefully dried, and kept in a well cloſed bottle.

Biſmuth is one of thoſe metallic ſubſtances which are partly ſeparated from acids by dilution with much water, and which cannot be kept diſſolved but by acids concentrated to a certain point, or when the acid is more than is ſufficient to ſaturate the metal. By the dilution of the acid, then, this operation is performed. The precipitate is very white; both becauſe a ſmall portion of acid remains united with it, which the water cannot take from it, and becauſe the nitrous acid has taken from the biſmuth moſt of its phlogiſton.

As biſmuth reſembles lead in many of its properties, ſome chemiſts obſerving that by mixing a ſolution of common ſalt with a ſolution of biſmuth in the nitrous acid, a white precipitate is formed, which alſo happens to ſolutions of ſilver and of lead, believed that in this precipitation the marine acid united with the biſmuth, and formed a *biſmuthum corneum*. But Mr. Pott, although he had been himſelf of this opinion, has ſhewn that the precipitation is cauſed merely by the water in which the common ſalt is diſſolved; ſince, when the ſolutions of biſmuth and of common ſalt contain the ſmalleſt poſſible quantity of water, no precipitation reſults from their mixture. Biſmuth, therefore, differs eſſentially from lead in this reſpect.

The chief uſe of the magiſtery of biſmuth is to enter into the compoſition of white paint uſed by ladies. It is preferred to all other whites from its ſuperior beauty, its luſtre, and an almoſt inſenſible tint of carnation, which renders it more ſimilar to the fineſt and whiteſt ſkin.

This advantage, which is very great, is counterbalanced by great faults. The ſkin is ſaid to be conſiderably ſpoiled by a continued uſe of it; it is alſo very apt to acquire a blackiſh color. Metallic ſubſtances and their calxes are known to be very apt to be impregnated with phlogiſton, when it touches them while it is in vapor, or in any other ſtate favorable to combination. By this means, whether they recover a part of the phlogiſton of which they have been deprived, or whether they receive it ſuperabundantly, they always acquire dark and blackiſh tints. But of all metallic calxes, that of biſmuth is one of the moſt ſuſceptible of this effect: its fine white becomes brown, and even leaden-colored, by a very ſlight expoſition to the phlogiſtic vapors; ſuch as the exhalations from houſes of office, from garlic, eggs, and particularly from liver of ſulphur. For this reaſon the white of biſmuth muſt be kept in well-cloſed bottles, otherwiſe it would be injured by circulating vapors which pervade paper coverings. From this property of biſmuth, it is rendered capable of affording a kind of ſympathetic ink. *See* INK (SYMPATHETIC).

Some artiſts prepare magiſtery of biſmuth by precipitating it from its ſolution in the nitrous acid, by a fixed alkali. But this method does not produce ſo good a white as the precipitation by water alone. The cauſe of this alſo is, that the calx of biſmuth very eaſily recovers its phlogiſton. Alkalis, however pure, always contain ſome ſuperabundant inflammable matter, and apply it to the metallic calxes which are precipitated, and particularly to the calx of biſmuth, which becomes more brown in proportion to the greater quantity which it takes of this inflammable matter. *See* Bismuth.

CCCCXXIX. **MAGISTERY *of* CORAL, CRABS-EYES, &c.** Coral, crabs-eyes, pearl, ſhells, chalk, and other ſubſtances of that kind, are all abſorbent and calcareous earths, eaſily ſoluble in nitrous acid, with which they form a nitre with an earthy baſis. If the ſolutions of theſe matters be treated like the mother-water of nitre; that is, if they are precipitated by a fixed alkali, and afterwards well waſhed, all theſe earths will be obtained in a very divided ſtate. The name of magiſtery is then given to them, together with the name of the ſubſtance which has been diſſolved and precipitated. All theſe magiſteries are nothing elſe but abſorbent earths, which differ little from each other, or from magneſia. For the method of preparing theſe magiſteries *ſee* Magnesia.

CCCCXXX. **MAGNESIA ALBA.** Magneſia is a white earth precipitated from the mother-waters of nitre and of common ſalt by a fixed alkali. It ought afterwards to be well edulcorated, to deprive it of all the ſaline particles it might retain.

To make magneſia, the mother-water of nitre, or of common ſalt, is placed in a large veſſel, and diluted with a conſiderable quantity of common water; then a liquid fixed alkali is gradually poured upon it, and the mixture is to be agitated, which preſently becomes turbid, and of a white milky color. In this manner alkali is to be added at different times, till no more precipitate is perceived; the liquor is to be further diluted with common water, if that be neceſſary for facilitating the earthy ſediment: when this ſediment is all formed, the liquor is to be decanted from it: it is then to be poured upon a filter of brown paper, ſupported by a cloth: pure water is poured upon it, till it is no longer capable of giving any taſte to the water: the earth is then to be formed into troches or cakes, and left to dry. This is *magneſia*.

The mother-waters of nitre and of common ſalt are almoſt entirely compoſed, the former of nitre and ſea-ſalt with earthy baſes, and the latter of ſea-ſalt with an earthy baſis. *See* Waters (Mother), Nitre, Nitre *with* Earthy Basis, Water *of the* Sea *and* Salt Fountains, Salt (Common), Salt (Sea) *with* Earthy Basis. Theſe ſalts are compoſed of nitrous and marine acids ſaturated with a calcareous earth, and are very deliqueſcent. They therefore do not cryſtallize; and great quantities of them remain diſſolved in the laſt portions of liquor from which no more cryſtals can be obtained. Fixed alkalis being capable of decompoſing all ſalts with earthy baſes, and of ſeparating their earth, do actually ſeparate it in the preſent operation. Magneſia is then nothing elſe than a very much divided calcareous earth. It is employed in medicine as an abſorbent earth, and is a very good one, from the fineneſs of its parts.

The mother-waters from which magneſia is to be precipitated, muſt neceſſarily be diluted in a very large quantity of water, becauſe the abſorbent earth diſſolved by the nitrous and marine acids, is there in ſo large a quantity, that when an alkali is added to it without dilution, no precipitation ſeems at firſt to take place. The molecules of earth, not being capable of moving freely and of joining each other, do not form ſenſible molecules, and remain almoſt in the ſame ſtate in which they were when they adhered to acids. But the ſeparation is nevertheleſs made, and ſo copiouſly, that the water of the mixture is found to be in too ſmall a quantity, and that the whole becomes ſolid. This almoſt ſolid coagulation, which happens when two very fluid liquors are mixed, aſtoniſhes perſons who do not underſtand the reaſon of it. It has accordingly been called the chemical miracle, *miraculum chemicum.* To prevent this coagulation, and to allow the earth to depoſite itſelf, a ſufficient quantity of water muſt be added.

After the precipitation is made, neutral ſalts with baſes of fixed alkali remain in the liquor, which differ according to the kinds of acids which formed the ſalts with earthy baſes, and according to the nature of the alkali employed for this decompoſition. Thus, if the mineral fixed alkali had been employed, the neutral ſalt formed in the mother-water of ſea-ſalt will be common ſalt, and the neutral ſalt formed by that alkali in the mother-water of nitre will be cubic nitre. If a fixed vegetable alkali has been employed, from the mother-water of common ſalt, the febrifugal ſalt of Sylvius may be obtained; and from the mother-water of nitre, not only that febrifugal ſalt, but alſo ordinary nitre may be obtained.

Hence, if magneſia be made in a very large quantity, the water, after the precipitate has been procured, ought not to be thrown away; as from it much good nitre and common ſalt may be obtained, according to the kind of mother-water employed. To obtain nitre, fixed vegetable alkali ought to be uſed; and to obtain common ſalt, the mineral alkali: the liquor is then to be evaporated, and cryſtals of theſe ſalts will be formed.

If the magneſia is not waſhed, it contains much of theſe ſalts. In that caſe, it would not be a ſimple abſorbent, but would partake of the virtues of theſe ſalts. It would even be purgative in a certain doſe: but as the quantity of ſalts which remains is always uncertain, when we intend that the magneſia ſhall contain any, it ought to be prepared in the ordinary method, and afterwards ſuch doſes of theſe ſalts as we ſhall judge proper may be added to it.

Some artiſts prepare magneſia without precipitation by an alkali. Their method is by evaporating the mother-water, and calcining the reſiduum in a crucible, to diſſipate the acids: but this method is improper, becauſe the magneſia by calcination acquires the property of quicklime.

If, inſtead of pouring fixed alkali into the mother-water, vitriolic acid be mixed with it, and if the mother-water has not been diluted with common water, a large quantity of a very white precipitate will be formed in it. Some authors have improperly called this precipitate magneſia; but it is of a very different nature from the earth properly ſo called. (n)

(n) This ſubſtance, diſtinguiſhed by the name *magneſia alba*, from the dark-colored mineral called alſo *magneſia*, or *mangeneſe*, has been accurately examined by Dr. Black. The experiments of that excellent chemiſt on this ſubject are related in the ſecond vol. of the *Eſſays Philoſophical and Literary, publiſhed at Edinburgh.* From theſe we learn the following reſults: 1. Magneſia is ſoluble with efferveſcence in vitriolic, nitrous, marine, and acetous acids. With vitriolic acid it formed cryſtals ſimilar in all reſpects to thoſe of the ſalt called *Epſom-ſalt.* With nitrous acid it formed cryſtals, which deliquiated in a moiſt air. With marine acid it did not form cryſtals; but the ſaline matter being evaporated to dryneſs, ſoon deliquiated by expoſure to air. With diſtilled vinegar it formed no cryſtals by evaporation; but a ſaline maſs, which, when

The ſediment formed by adding vitriolic acid, far from being a pure calcareous earth, conſiſts of that earth which this acid takes from the nitrous and marine acids, and forms with it a ſelenites. This ſelenites appears as a precipitate; becauſe, as it is very little ſoluble in water, it cannot be all ſuſpended or diſſolved in the liquor: but if a large quantity of water, eſpecially hot water, be added, this pretended magneſia either does not appear, or afterwards diſappears by being again diſſolved. This precipitate is not applied to any uſe. *See* SELENITES.

CCCCXXXI. MAGNESIA. (o)

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warm, was viſcid, reſembling glue in color and conſiſtence, and when cold, was brittle. 2. By calcination, it loſt $\frac{7}{12}$ of its weight. When calcined, it did not efferveſce with acids, whence the ſubſtance loſt by calcination was chiefly fixable air. This air, and almoſt all its weight loſt by calcination, was reſtored to it by ſolution in vitriolic acid, and precipitation from thence by a mild fixed alkali, the air of which it abſorbed. 3. By the laſt mentioned properties (2) it ſeemed analogous to calcareous earths, but differed from theſe earths, in the nature of the ſalts formed by it with acids (1), and alſo in other properties; but eſpecially in this, that even when calcined, it was not ſoluble in water. The Author of the Dictionary, therefore, improperly calls it a calcareous earth; this name being applicable to ſuch earths only as are convertible into quicklime. 4. It was precipitated from acids by volatile alkali. 5. When uncalcined, it precipitated calcareous earth from acids. When calcined, or otherwiſe deprived of air, it did not precipitate theſe earths: hence its attraction to acids is not greater than that of theſe earths; but the cauſe of the former precipitation was this, that the ſum of the forces which tended to join the calcareous earth with the fixable air of the magneſia, and the magneſia with the acid, was greater than the ſum of the forces which tended to join the calcareous earth with the acid, and the magneſia with the fixable air. 6. When uncalcined, or united with air, it precipitated lime from lime-water; which ſhews, that the calcareous earth had a ſtronger power to combine with fixable air than magneſia had, ſince the former earth took this air from the latter earth; by which means the former was rendered mild and unſoluble in water, and therefore was precipitated. This property ſuggeſted to Dr. Alſton a method of procuring ſweet water at ſea, by adding magneſia to water, the putrefaction of which had been prevented by the previous addition of quicklime. 7. By diſtillation of three ounces of magneſia, five drams of water, containing ſome ſmall portion of volatile alkali, were obtained.

(o) MAGNESIA, or MANGANESE, is commonly conſidered as an ore of iron; but the experiments of Mr. Pott and Mr. Cronſtedt ſhew, that this ſtone contains little or no iron, and therefore the latter author has made a diſtinct order of this earth, which he calls *terræ magneſiæ*. Its colors are dark-grey, black, red, or white. Its texture is ſtriated, or with concentric fibres, or indeterminate. It has the following properties: 1. It does not efferveſce with acids; they, however, diſſolve ſome part of it, eſpecially when it is calcined: ſpirit of vitriol acquires from it a roſe color: aqua regia alſo acquires color, eſpecially from the black kind. From theſe ſolutions fixed alkalis precipitate a white earth. 2. A ſmall quantity of this earth, mixed with glaſs frit, gives red or purpliſh colors to the glaſs. By continuing the fuſion, theſe colors diſappear, and alſo other tinges which the glaſs may have accidentally received; hence it is uſed to produce colorleſs glaſs. Larger quantities of it are added when a deep purple glaſs is required. It is alſo uſed to give a glazing to pottery. 3. Fuſed with nitre or with fixed alkali, it gives to warm water various colors, green, purple, red, or blue, which change by agitating the water. 4. Cronſtedt affirms, that it deflagrates with nitre. Pott ſays, it does not. 5. Cronſtedt ſays, that he has ſometimes extracted a ſmall portion of tin from magneſia. 6. The ſame author affirms, that the colors given by magneſia to glaſs are eaſily deſtroyed by calxes of arſenic or of tin. Whence does its property

CCCCXXXII. MAGNET. (p)

CCCCXXXIII. MALT. The grain is ſo called which has been made to germinate, and afterwards dried, ſo as to become fit for the ſpirituous fermentation, or for making beer. *See* BEER.

CCCCXXXIV. MANNA. *See* SUGAR.

CCCCXXXV. MARBLE. (q)

CCCCXXXVI. MARCASITE. This name has long been given indifferently to all ſorts of minerals, to ores, pyrites, and to ſemi-metals. Lately it ſeems to be confined to pyrites; and Mr. Wallerius propoſes to apply it only to ſuch pyrites as are regularly formed. This ſeems to be better than to leave it a vague and indeterminate ſignification, from the ambiguity and obſcurity which might thereby be introduced. *See* PYRITES.

CCCCXXXVII. MARLE. (r)

CCCCXXXVIII. MARS is the name of a planet which chemiſts have given to iron, and which is ſtill much uſed in medicine and chemiſtry. *See* IRON.

CCCCXXXIX. MASTIC. (r)

CCCCXL. MATRASS. A matraſs is a bottle with a neck more or leſs long, uſed in chemiſtry for making digeſtions and macerations. Matraſſes are alſo uſed as receivers. Their form is different, ſome of them being ſpherical, which is the ordinary ſhape; others flattened at the bottom, called *matraſſes with a flat bottom*; and others having the figure of an egg, which laſt kind are called *philoſophical eggs*. Theſe matraſſes are choſen according to the operations intended. The moſt convenient of all, when we do not mean to operate on a large quantity of matter, are bottles of thin glaſs, known by the name of *medical phials*; becauſe theſe phials are very cheap, are made of good glaſs, and may be quickly heated, ſo that the liquor contained ſhall boil without danger of being broken. This advantage they owe to their thinneſs. Such phials are very uſeful in a laboratory; and therefore a number of them ought always to be kept there. *See* VESSELS.

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of tinging glaſs proceed? Does it contain any of the known volatile metallic ſubſtances, or a new ſemi-metal?

(p) MAGNET. Magnets are iron-ores, from which a conſiderable portion of iron may be extracted. Ne[illegible] ſays, that they are almoſt totally ſoluble in ſpirit of nitre, and partially in the vitriolic and marine acids.

(q) MARBLES All thoſe calcareous ſtones are called, which are hard, which have [illegible] texture, are capable of receiving [illegible] poliſh, and which are conſidered as [illegible] For their properties, *ſee* EARTHS ([illegible]).

(r) MARLE is an earth compoſed of different proportions of argillaceous and of calcareous earths. Its properties vary in degree according to the proportions of theſe earths. Marles effervefce with acids, which property they receive from the calcareous earth. They are fuſible by fire, as all mixtures of theſe two earths are. By a leſs heat, if the calcareous earth predominates, they are calcinable into a kind of quicklime; and if the clay predominates, they may be changed by fire into hard maſſes capable of ſtriking ignited ſparks from ſteel.

(s) MASTIC is a reſin almoſt totally ſoluble in ſpirit of wine, but not at all in water. It becomes ſoft and tough, like wax, by being chewed. It is uſed as an ingredient in varniſhes.

CCCCXLI. **MATRIX.** (t)

CCCCXLII. **MATT.** Ores not perfectly deprived of their ſulphur, when fuſed, are called *matt.* It is obtained in the firſt fuſion for the extraction of metal from ſome ores. *See* SMELTING *of* ORES.

CCCCXLIII. **MENSTRUUM.** Menſtruum is a word ſynonimous with ſolvent. *See* SOLUTION.

CCCCXLIV. **MERCURY.** Mercury is the name of a planet, which is alſo given to the metallic ſubſtance called *quick-ſilver* But as mercury is the moſt general name, we ſhall here relate the principal properties of this metallic ſubſtance.

Mercury is a metallic ſubſtance of a ſhining white appearance, entirely ſimilar to that of ſilver. It is habitually fluid, and conſequently we cannot diſcover either its ductility or the tenacity of its integrant parts.

Its ſpecific gravity is very great: next to gold and platina, it is the heavieſt of all metallic ſubſtances, and even of all known natural bodies. It loſes about $\frac{1}{13}$ part of its weight in water, and a cubic foot of mercury weighs 947 pounds.

Neither air, water, nor the united action of theſe two elements, appear to make any ſenſible impreſſion upon mercury; nor is it more ſuſceptible of ruſt than the perfect metals. Its ſurface tarniſhes, nevertheleſs, to a certain degree, and more quickly than gold and ſilver, when it is expoſed to the air: but this is becauſe the duſt which floats in the air quickly fixes upon its ſurface. The watery vapors alſo which float in the air ſeem alſo to be attracted by the mercury.

Mercury may eaſily be cleanſed from thoſe extraneous matters which adhere only ſlightly to it, by making it paſs through a new, clean, and cloſe cloth, and afterwards by heating it. When mercury has been thus purified, and is free from all metallic allay, it is conſiderably fluid. A phoſphoric light is produced by ſhaking in the dark ſuch mercury contained in a barometer. Its integrant parts, like thoſe of melted metals, ſeem mutually to attract each other, and always acquire a convex or ſpherical form when they touch bodies with which they have no tendency to unite.

Mr. Lemeri the younger aſſerts, that mercury loſes no weight by being kept in boiling water; and therefore that water diſſolves none of it. Nevertheleſs, many good phyſicians are of opinion, that water which has been boiled upon mercury has the property of killing worms and other inſects; from which we may ſuſpect, that ſome mercurial parts are diſſolved by the water, although their quantity is too ſmall to be rendered ſenſible by a balance. Theſe experiments deſerve to be repeated with due attention.

Mercury, when expoſed to fire, preſents many remarkable phenomena. It ſeems to ſuffer no change from a heat that is not ſuperior to that of boiling water. With a greater heat it is entirely diſſipated in vapors, like other volatile bodies. It undergoes no alteration by having been thus reduced into vapor; for if the evaporation be made in cloſe veſſels, that is, if the mercury be diſtilled, its vapors when condenſed will form the ſame mercury as before the operation. Mercury remains unchangeable by repeated diſtillations. Boerhaave diſtilled 18 ounces of mercury 500 times, without perceiving any other change than that its fluidity and ſpecific gravity were a little encreaſed, and that ſome grains of a fixed matter remained: which ſmall changes were probably produced by a purification of the mercury, rather than by any real alteration of it. The vapors of mercury, like thoſe of all other volatile bodies, if they cannot eſcape, or be condenſed, cauſe violent exploſions. Mr. Hellot, of the Academy of Sciences, ſays, that he was preſent at an experiment of this kind. A perſon pretending to fix mercury had encloſed ſome of it in an iron box cloſely welded. When the mercury was heated, it burſt the iron box, and diſſipated in inviſible vapors.

(t) MATRIX. The matrix of ores is the earthy and ſtony ſubſtances in which theſe metallic matters are generally inveloped. Theſe are very various, generally ſpar, quartz, fluors, or horn-blend. *See note to the article* ORES.

By digeſtion in a ſtrong heat, continued during ſeveral months, mercury undergoes a more ſenſible alteration; its ſurface being gradually changed into a reddiſh earthy powder, without any metallic luſtre, which floats upon the ſurface of the fluid mercury, without incorporating with it. Thus any quantity of mercury may be entirely converted into a red powder. For this purpoſe only the proper time and veſſels are required. As mercury, thus changed, reſembles a metallic precipitate; and as, for this purpoſe, no addition is neceſſary; this preparation is called *mercurius præcipitatus per ſe*, or mercury precipitated by itſelf.

The ſtrongeſt heat which mercury can ſuſtain is neceſſary for the preparation of this precipitate *per ſe*. For Boerhaave, who made long continued experiments upon this ſubſtance, with a patience unequalled even by the ſearchers for the art of making gold, kept mercury in digeſtion during 15 years, without obſerving any change, unleſs that upon its ſurface a little black powder had formed, which by trituration was eaſily reducible into fluid mercury. *See* PRECIPITATE PER SE.

Till lately it was believed that the fluidity of mercury was as eſſential to it in its natural ſtate as its volatility: ſo that thoſe even who had labored to render it fixed and ſolid, expected to attain their purpoſe only by producing a great change upon its nature. But at preſent we are aſſured that by a ſufficient degree of cold it may be rendered ſolid and malleable like the other metals. This truth, which had been conjectured by theoretical chemiſts, has been lately demonſtrated by the Members of the Academy at Peterſbourgh. Theſe philoſophers availed themſelves of the intenſe cold on Dec. 25, 1759, which they further encreaſed by the artificial methods known, and particularly by the mixture of ſpirit of nitre with ſnow, till Mr. de Liſle's thermometer was ſunk to the 213th degree. They then perceived that the mercury in the thermometer no longer continued to mark the degrees of cold, and ſuſpected that it had loſt its fluidity. Having broken their thermometer, they found that their mercury was actually conſolidated. They repeated this experiment upon other thermometers, and found that it ſucceeded ſo completely, that after having broken one of theſe inſtruments, they extracted the mercury in a ſolid ſtate, which reſembled a ſmall globe of ſilver, with a flexible ſilver wire attached to it. They ſtruck this mercurial globe ſeveral times with a hammer, and perceived that it was thereby flattened and extended like a ductile metal. Mr. Poiſſonnier, Phyſician of the Faculty of Paris, Phyſician to the King, and Member of the Academy at

Peterſbourgh, who then happened to be in Ruſſia, was preſent, and one of the operators at this important experiment, and was the perſon who firſt ſent a particular account of it to the Academy of Sciences at Paris *(u)*. By this capital experiment it is then well eſtabliſhed and authenticated, that mercury is, like other metals, fluid or ſolid, according to the greater or leſs quantity of fire with which it is penetrated; that if we only ſee it in a fluid ſtate, it is becauſe it is ſo fuſible that ſo ſmall a degree of heat can keep it fluid, that even in the greateſt natural colds, a ſufficient quantity of heat always remains for that purpoſe.

This exceeding fuſibility of mercury, and its great volatility, together with its great denſity and gravity, are properties which appear contrary and incompatible, to be found in the ſame body, and ſo eminently. In fact, the denſity, gravity, and ſolidity of metals, leave no doubt but that the earthy element enters in a great quantity into their compoſition; and beſides, by the calcination of imperfect metals, this element is in ſome meaſure developed, and rendered ſo ſenſible by eſſential properties, that it undoubtedly makes part of metals. The extreme denſity and gravity of mercury ſeem to prove no leſs evidently that much of the earthy element enters into the compoſition of that ſubſtance. But on the other ſide, ſolidity and fixity ſeem to be eſſential properties of the earthy principle. How then ſhall we conceive, that a ſubſtance compoſed almoſt entirely of the moſt fixed and refractory principle, ſhould be exceedingly volatile, and perhaps the moſt fuſible of all bodies? This moſt undoubtedly proceeds from the preſence of ſome other principle which is eminently volatile and fuſible. But what is this principle? Is it phlogiſton? or that principle which Becker has mentioned, but not aſcertained, and which he calls *mercurial earth?* Is it the union of the inflammable principle and of this mercurial earth? Theſe certainly are objects worthy the curioſity of thoſe who have taſte and talents for the ſublimeſt reſearches in chemiſtry.

We proceed now to the other properties of mercury, which it diſcovers when combined with the principal chemical agents.

(u) The validity of this experiment, which ſeems to aſcertain the fixation of mercury by cold, has been queſtioned by counſellor Lehman. According to this author, the mercury employed by profeſſor Braun in the recited experiment had been diſtilled in the common method through water, and the water only in that experiment was frozen, but not the mercury. He alſo affirms, that having diſtilled mercury without water, and having carefully purified it from all watery particles, he could not congeal the mercury by artificial cold, altho' he at the ſame time did congeal common mercury. But I think that we muſt aſſent to the fixability of mercury by cold, as affirmed by the academicians of Peterſbourgh, unleſs we diſbelieve what they aſſert concerning the ductility of the mercury thus hardened, which could certainly not be given by the congelation of adhering water.

Nevertheleſs, mercury is ſaid to attract powerfully moiſture from the air. The exploſions occaſioned by expoſing mercury ſuddenly to heat in cloſe veſſels are ſaid by M. [illegible]elle to be produced by water adhering to the mercury. The water commonly obtained in diſtilling mercury which has been expoſed to moiſt air, has induced a belief of the convertibility of mercury into water. Neuman ſays, that he has obſerved that the weight of mercury was greater in winter than in ſummer. Probably this difference proceeded from the mercury having acquired more moiſture from the air in the former than in the latter ſeaſon. *See* ENCYCLOP. tom. X. p. 273.

Vitriolic acid in its original ſtate does not act, or but very weakly, upon mercury. Theſe two ſubſtances cannot be united together, unleſs the acid be very highly concentrated, and a very ſtrong heat applied. Theſe two conditions are united in diſtillation. Vitriolic acid, poured upon mercury and diſtilled, becomes more and more concentrated; and as it acquires a great heat when it is concentrated, it then acts upon the mercury, diſſolves it, and reduces it to a ſaline, white maſs.

In this operation we obſerve, that the portion of acid which paſſes in diſtillation is very much of the volatile ſulphureous nature, which might induce us to ſuſpect that the acid ſeizes part of the inflammable principle of the mercury. Nevertheleſs, when we afterwards ſeparate the vitriolic acid from the mercury, we find that this metallic ſubſtance has received no alteration. This volatile ſulphureous quality, therefore, ſeems more probably to be given to the vitriolic acid by ſome inflammable matter which the mercury had ſuperabundantly, as moſt other metallic matters generally have. This deſerves a more particular examination.

When the ſaline-mercurial combination which remains in the retort is mixed with pure water, it divides into two different matters, one of which is perfectly ſoluble in water, and the other precipitates in form of a white powder, if the water be cold; and of a yellow powder, if the water be hot, and in ſufficient quantity. The portion which remains diſſolved in the water is a combination of mercury with as much vitriolic acid as is neceſſary to give it a ſaline quality. It is a ſalt with a metallic baſis, cryſtallizable by evaporation of the water. It ought to be called *vitriol of mercury*. The precipitated portion is almoſt entirely pure mercury, which retains too little acid to give it a ſaline quality, or ſolubility in water. It may be totally deprived of its acid, according to Mr. Beaumé, by a ſufficient lavation with hot water. This precipitate becomes more and more yellow, when it is waſhed with hot water; it is a violent emetic, and is known by the name of *turbith mineral*. *See that article.*

If, inſtead of treating with water the combination of vitriolic acid and mercury which remains in the retort after diſtillation, it be cohobated ſeveral times with vitriolic acid, Lemery ſays, that the mercury becomes more and more impregnated with acid, and at laſt becomes a very corroſive liquor, which ſome chemiſts have improperly called *oil of mercury*.

If the combination of vitriolic acid with mercury be expoſed to fire, the greateſt part of this acid will be expelled; and this remarkable thing happens, that mercury treated thus with vitriolic acid ſuſtains a greater heat, and conſequently ſeems to be ſomewhat more fixed than when it is pure.

Nitrous acid diſſolves mercury very readily; and this ſolution preſents phenomena very ſimilar to thoſe of the ſolution of ſilver by the ſame acid. This acid ought to be very pure; the ſolution may be made without heat; it is corroſive, and blackens the ſkin, in the ſame manner as the ſolution of ſilver does. From this ſolution may be obtained by cryſtallization a nitrous mercurial ſalt, which may be called *mercurial nitre*. If this ſalt be expoſed to the action of fire, much of the nitrous acid will be driven from it in the ordinary form of red vapors; and when the acid quits the mercury, the ſalt, which is at firſt very white, becomes yellow, then orange-colored, and laſtly red. Mercury treated with this acid becomes alſo more fixed. Nevertheleſs, by a ſufficient heat it may be ſublimed.

The red powder which remains after the evaporation of the nitrous acid has the appearance of mercury precipitated by itſelf. It is called *red precipitate*, but improperly, for it is not a precipitate. *See* PRECIPITATE. When ſpirit of wine has been poured upon it and burnt off, it is called *arcanum corallinum*. *See* PRECIPITATE (RED).

Marine acid when liquid does not act ſenſibly upon mercury in its ordinary ſtate, even when aſſiſted with a boiling heat. But when this acid, very concentrated and reduced into vapors, meets mercury alſo in vapors, theſe two bodies eaſily unite together, and even intimately. Hence reſults a marine ſalt with baſis of mercury, the cryſtals of which have the form of flattened needles. It is called *corroſive ſublimate mercury*, or only *corroſive ſublimate*, becauſe it is always made by ſublimation, and is at the ſame time a very violent corroſive.

Corroſive ſublimate may be made in ſeveral methods. The moſt common is to take a ſolution of mercury evaporated to dryneſs, to mix it with a quantity of calcined martial vitriol and of decrepitated common ſalt equal to the quantity of mercury diſſolved, and to proceed to ſublimation by expoſing the mixture to fire in a matraſs ſet in a ſand-bath. On one ſide the acid of vitriol diſengages the acid of common ſalt which riſes in vapors. On the other ſide, the mercury is reduced into vapors by the heat. Theſe two bodies combine together in that ſtate, and form a ſalt, which being itſelf volatile, attaches itſelf in the upper and colder part of the matraſs, where it forms a very white and ſhining cryſtallized incruſtation, which is the corroſive ſublimate. The other methods of making this ſalt are founded on the ſame principles. They will be found under the article CORROSIVE SUBLIMATE.

This ſalt is of a ſingular nature, and differs much from all the other combinations of mercury with other acids. Altho' it is extremely cauſtic, and is capable of receiving ſtill a conſiderable quantity of mercury, as we ſhall afterwards obſerve when we ſpeak of ſweet mercury, (which qualities indicate an imperfect ſaturation of the acid) it nevertheleſs has none of the properties obſervable in thoſe ſalts whoſe acids are imperfectly ſaturated. It cryſtallizes well, and very eaſily; ſo far is it from being deliqueſcent, as all theſe ſalts are, it is difficultly ſoluble in water, and requires a large quantity of boiling water to diſſolve it entirely. It is conſequently a ſalt which cryſtallizes by cold. Its cryſtals are of the ſame form as thoſe obtained by ſublimation, and croſs each other irregularly. They reſemble a heap of large ſword-blades or poignards thrown careleſly together.

If corroſive ſublimate be expoſed to fire, it will again be ſublimed in its original form, without being decompoſed, or at leaſt only inſenſibly. The mercury then, ſo far from receiving any fixity from the marine acid, as it does from the vitriolic and nitrous acids, ſeems on the contrary to be rendered more volatile. This phænomenon is analogous to thoſe which are exhibited by other metallic ſubſtances with marine acid, the union of which renders all theſe ſubſtances more or leſs volatile. This acid ought to produce this effect more ſtrongly upon mercury, as it is itſelf conſiderably volatile.

This property as well as the others which are peculiar to the combination of marine acid with mercury, are naturally deducible from the preſence of mercurial earth exiſting abundantly in both theſe ſubſtances, if Becker's opinion upon this ſubject was ſufficiently proved. *See* SUBLIMATE (CORROSIVE).

The affinity of marine acid with mercury is ſo great, that it overcharges itſelf in ſome meaſure with a conſiderable quantity of that metallic matter. If corroſive ſublimate be triturated in a glaſs mortar with fluid mercury, it will receive the mercury and acquire a blackiſh color. By thus adding mercury till it no longer is extinguiſhed (for this kind of combination is called *extinction*) which is known by the globules of mercury not diſappearing, we ſhall find that corroſive ſublimate is capable of abſorbing or extinguiſhing about three quarters of its weight of freſh mercury. And if this new mixture be ſubjected to ſublimation, the combination of mercury with corroſive ſublimate is compleated, and a new ſublimate is formed, in which the quantity of mercury is much greater than in corroſive ſublimate. When this matter has been ſublimed thrice, to render the combination more perfect and intimate, the ſublimate is then called *mercurius ſublimatus dulcis*, or more frequently *ſweet mercury*, becauſe the mercury which is then united to the marine acid forms a compound which is no longer cauſtic, and which is taken internally as a purgative. *See* MERCURY (SWEET). It is alſo called *aquila alba*, the white eagle, and this Latin name is ſtill in uſe.

Corroſive ſublimate is not only rendered leſs cauſtic by this addition of mercury, which changes it into ſweet mercury, but alſo the properties of the marine acid, and even its ſaline qualities are, almoſt entirely aboliſhed. Sweet mercury has not then, properly ſpeaking, but the external appearance of a ſaline matter. It is almoſt entirely unſoluble in water, which is the moſt diſtinguiſhing mark of ſalts.

If ſweet mercury be ſix times ſublimed, it loſes more and more of its purgative quality, and at laſt all of it. This change is produced either by a loſs of part of the acid each time, or by the combination betwixt the acid and mercury being rendered more intimate. In this ſtate it is called *mercurial panacea*, or merely *panacea*. The panacea taken internally in ſufficient doſes can then only produce ſalivation. *See* MERCURY (SWEET) *and* PANACEA.

The combinations of mercury with the vitriolic, nitrous, and marine acids, may be decompoſed by all intermediate ſubſtances, which having in general a ſtronger affinity with acids than metallic ſubſtances, decompoſe all metallic ſolutions by acids. Theſe intermediate ſubſtances are abſorbent earths, and alkaline ſalts, both fixed and volatile.

Lime-water mixed with a ſolution of corroſive ſublimate, precipitates the mercury in form of a red brick-colored powder. This mixture is employed in ſurgery under the name of *phagedenic water*. It is uſed for cleanſing ulcers, particularly thoſe which are venereal.

Fixed alkalis precipitate mercury from its ſolutions in a reddiſh powder; volatile alkali precipitates corroſive ſublimate in a white powder, and the ſolution of mercury in nitrous acid in a grey ſlate-colored powder. In general, the colors of the mercurial precipitates are various, and theſe colors depend, like thoſe of all other metallic precipitates, on the degree of diviſion of parts, and on the quantity of ſaline matter and of phlogiſton retained by theſe precipitates. *See* PRECIPITATE.

Fixed and volatile alkalis do not act, or but inſenſibly, on mercury, in its proper ſtate; but they can diſſolve it, as well as all other metallic matters, when they can be applied to theſe metallic matters very much divided, as, for example, previouſly diſſolved by acids. Thus when a ſolution of mercury, with more acid than is neceſſary to diſſolve the mercury, is poured into a very concentrated alkaline liquor, the precipitate formed upon firſt mixing the liquors will be again diſſolved, and will diſappear. The volatile alkali may by this management diſſolve a very conſiderable quantity of mercury.

Laſtly, vegetable acids which ſcarcely have any action upon ordinary mercury, are alſo capable of diſſolving it when it is ſufficiently divided. Thus if we pour a large quantity of diſtilled vinegar upon mercury precipitated by a fixed alkali from its ſolution in nitrous acid, this precipitate will be eaſily diſſolved again by help of a little heat, and from this combination a mercurial ſalt of a ſingular nature will be formed.

The acid of vinegar, and probably all other vegetable acids, ſeem to be capable of contracting a very intimate union with mercury; for the *acetous mercurial ſalt* which we have juſt mentioned is not only cryſtallizable, but is even difficultly ſoluble in water. Hence, the phlegm of the vinegar not being in ſufficient quantity to keep the acetous mercurial ſalt diſſolved without heat, when it is made by the proceſs deſcribed, this ſalt cryſtallizes in great quantity, when the liquor cools. Its cryſtals are ſmall, ſhining, thin plates, floating in the liquor like pieces of ſilver leaf.

From all the ſolutions of mercury we have mentioned, we may ſee, that this metallic matter is capable of being combined with all acid or alkaline ſaline ſubſtances, but with more or leſs facility and intimacy. Of all the acids, the nitrous diſſolves mercury moſt eaſily, as it does in general all metallic ſubſtances; but it has not the ſtrongeſt affinity with mercury; on the contrary, it ſeems to be that which contracts with it the leaſt intimate union, as we may ſee from the following experiments.

If into a ſolution of mercury made by ſpirit of nitre, vitriolic acid be poured, or the ſolution of any neutral ſalt containing this acid, the liquors will be rendered turbid; and when they are hot, a yellow precipitate will be formed, exactly ſimilar to that which is obtained by pouring water upon the combination of vitriolic acid with mercury, that is to ſay, turbith mineral. This effect cannot happen but becauſe the vitriolic acid is joined to the mercury, which it ſeparates from the nitrous acid.

As this experiment is very manifeſt, as the turbith mineral is eaſily known, and as it may be formed from this ſolution of mercury in the nitrous acid, not only by the vitriolic acid when diſengaged, but alſo by any ſalts which contain that acid; this ſolution of mercury, therefore, affords a convenient method of diſcovering the preſence of that acid in many chemical experiments, and particularly in examining mineral waters. Accordingly, it is much uſed for that purpoſe; and is, with regard to the vitriolic acid, what the ſolution of ſilver in the nitrous acid is to the marine acid. *See* WATERS (MINERAL).

Marine acid, common ſalt, and in general all ſalts which contain this acid, mixed in a ſimilar manner with a ſolution of mercury in nitrous acid, occaſion a precipitate by the action of the marine acid upon the mercury, which it ſeparates from the nitrous acid, and with which it unites, forming a combination, which appears as a white precipitate, and is accordingly known by the name of the *white precipitate.* We muſt obſerve upon this ſubject, that that precipitate which is only a combination of marine acid with mercury, appears in theſe experiments as a precipitate, only becauſe it requires more water to keep it diſſolved than is to be found in theſe liquors; otherwiſe this mercurial ſalt would remain diſſolved, and would not become ſenſible. In this reſpect it differs eſſentially from turbith mineral, which is inſoluble in water.

The reaſon why this mercurial ſalt is much leſs ſoluble in water than the nitrous mercurial ſalt, is, that the marine acid is more intimately joined than the nitrous acid with the mercury; and alſo becauſe marine acid has ſo ſtrong an affinity with mercury, that it overcharges itſelf with that metallic matter, whenever it meets with a ſufficient quantity of it, as in the preſent experiment. For if we add to the white precipitate, to corroſive ſublimate, or to any other combination of marine acid with mercury, a much greater quantity of this acid diſengaged, theſe ſaline mercurial matters will charge themſelves with it ſuperabundantly, and will become ſo much more ſoluble in water, as they ſhall have received a larger quantity of this acid, according to the general rule. *See* SALTS.

Hence if white precipitate be made by pouring a conſiderable quantity of diſengaged marine acid into a ſolution of mercury by ſpirit of nitre, the precipitate ought to be re-diſſolved: and it accordingly is ſo, as Geoffroy, Junker, and Pott, have obſerved. As in this experiment, mercury is found diſſolved in a liquor containing the nitrous and marine acids, ſome chemiſts have imagined that mercury was ſoluble in aqua regia. Nevertheleſs nothing appears leſs certain than that concluſion. For it is very poſſible that mercury may be kept diſſolved by a ſuperabundant quantity of marine acid, with which only it is really united, and that the nitrous acid ſhould contribute nothing to this ſolution. Beſides, if the nitrous and marine acids could be both united to the ſame mercurial parts, why do the white precipitate and corroſive ſublimate, both made by help of a large quantity of nitrous acid, contain only the marine acid? The ſmalleſt veſtige of nitrous acid cannot be diſcovered in them.

Mr. Pott, in his Diſſertation on Common Salt, mentions another fact, which ſeems to prove not only, that mercury is ſoluble in aqua regia, but alſo that nitrous acid may ſeize upon that metallic matter excluſively of the marine acid. Mr. Pott's experiment conſiſts in pouring ſpirit of nitre upon corroſive ſublimate, by which he obſerved that ſpirit of ſalt was diſengaged in vapors.

A modern author draws from this experiment a conſequence againſt the greater affinity of the marine acid than of the nitrous with mercury, ſuppoſed by all chemiſts, and even againſt the doctrine concerning the tendencies of bodies to one another according to certain laws, called affinities. But, I believe, we may affirm that this experiment is only capable of impoſing upon us at firſt view, and not when we examine circumſtances attentively.

If indeed ſpirit of nitre be poured upon corroſive ſublimate, and particularly if the mixture be heated, we may obſerve the uſual phenomena of ſubſtances acting upon each other, that vapors are diſengaged, not of pure marine acid, but of aqua regia; and if the quantity of nitrous acid be ſufficiently large, that the corroſive ſublimate will be entirely diſſolved in it. But we muſt obſerve upon this ſubject, that as the quantity of mercury is very conſiderable in corroſive ſublimate, we cannot be ſurprized that nitrous acid, which has great diſſolving power upon this metallic matter, and which probably finds it not ſufficiently defended by marine acid, ſhould exerciſe upon it part of its action; but on the other ſide, as nitrous acid fixes mercury a little, and as the mixture undergoes a certain degree of heat, it is ſcarcely poſſible but that a certain quantity of marine acid ſhould diſengage itſelf. But we may eaſily perceive that this effect is produced by the concurrence of theſe two circumſtances, rather than by a ſuperior affinity of the nitrous acid to the marine, with mercury. For when theſe two cauſes ceaſe to act, that is, when the mixture becomes cool, and the action of the nitrous acid is over, the corroſive ſublimate is ſeen to cryſtallize very quickly even in the nitrous acid, and in as large a quantity as before the experiment.

This is not the only fact which furniſhes ſpecious objections againſt even the moſt manifeſt affinities. But in good philoſophy, when a ſingle fact is found to contradict many others well eſtabliſhed, it ought to be examined very attentively, and in all its circumſtances, before the conſequences it ſeems to contain ought to be inferred. We ſhall now return to our examination of white precipitate.

This combination of marine acid with mercury, being expoſed to the action of fire in cloſe veſſels, is ſublimed into a ſaline maſs, which is conſidered by Lemery as a ſweet mercury, by others as a corroſive ſublimate, and, laſtly, by ſome chemiſts as being in an intermediate ſtate betwixt corroſive ſublimate and ſweet mercury. The laſt opinion ſeems to be the moſt probable; for the ſublimate formed by white precipitate is probably not often charged with a ſufficient quantity of marine acid to form corroſive ſublimate, at leaſt if by that expreſſion we underſtand mercury ſublimed, and united with the greateſt poſſible quantity of marine acid; and on the other ſide, this ſublimate from white precipitate probably contains too little mercury to conſtitute ſweet mercury. But as the marine acid and mercury may be united in very different proportions, according to the ſtate in which they are preſented to each other, in this reſpect very conſiderable differences ought to be found in white precipitates, according to the methods of preparation. If, for example, mercury be precipitated by a large quantity of diſengaged marine acid, this mercurial precipitate will moſt probably contain a much larger quantity of acid, than a precipitate made by adding common ſalt to the ſolution of mercury. If this be true, we need not be ſurprized that chemiſts ſhould diſagree in their opinions concerning the degree of corroſive quality to be attributed to this ſublimate from white precipitate.

We have ſeen above, that the combinations of mercury with acids may be decompoſed, as all metallic ſolutions may, by earths and by alkalis both fixed and volatile. They may be decompoſed alſo, and particularly corroſive ſublimate may, by ſeveral metallic ſubſtances, ſuch as tin, regulus of antimony, and copper.

Corroſive ſublimate, being mixed with tin and ſubjected to diſtillation, may be decompoſed. The marine acid is applied to the tin, a part of which it carries with it in diſtillation, and with which it paſſes in form of an acid, ſmoking liquor. This acid is called the LIQUOR (SMOKING), *or* SMOKING SPIRIT *of* LIBAVIUS; which *ſee.*

Antimony or its regulus, being mixed and diſtilled with corroſive ſublimate, alſo decompoſe it; the regulus taking the marine acid from the mercury, and paſſing with that acid in form of a thick liquor, which congeals by cold, and is known by the name of Butter *of* Antimony. *See that article.*

If very clean plates of copper be ſteeped in a ſolution of corroſive ſublimate, the acid of that ſalt will attack the copper, and the mercury will be depoſited upon the ſurface of the copper, with its metallic luſtre, which always happens when one metal is precipitated by another. *See* Precipitation *and* Precipitate.

As mercury revived is always fluid, and therefore capable of being allayed with any metallic matter which it can touch, it amalgamates in the preſent experiment with the ſurface of the copper, and forms there a beautiful, white, and ſhining ſilvering, capable of ſurprizing perſons ignorant of theſe effects, and of making them believe that copper is thus changed into ſilver. But to make this experiment ſucceed well, we muſt add ſome marine acid, or ſome ſal ammoniac to the ſolution of corroſive ſublimate. This experiment ſucceeds equally well with the ſolution of mercury in ſpirit of nitre, but always better when the acid is larger in quantity than is ſufficient to diſſolve the mercury. The ſurface of the copper immerſed in theſe liquors becomes inſtantly ſilvered, and then it muſt be immediately withdrawn, waſhed in clean water, and wiped by rubbing it with a dry cloth.

When corroſive ſublimate and the other combinations of mercury with acids are decompoſed by proper intermediate ſubſtances, the mercury is always by that operation *revived*, that is, reduced to a fluid ſtate, and is obtained in that ſtate when the operation is made by diſtillation, by giving a heat ſufficient to raiſe it. But when the intermediate ſubſtance is a compound body, ſuch as antimony, which contains a principle capable of uniting and ſubliming with mercury; then the mercury which is diſengaged from the corroſive ſublimate, inſtead of being revived, makes part of a new combination, and is ſublimed in form of cinnabar, if antimony was uſed, from the union it contracts with the ſulphur of the antimony. *See* Butter *of* Antimony, *and* Cinnabar.

Sulphur acts ſtrongly on mercury. If theſe two ſubſtances be triturated together, the mercury will be eaſily divided; its molecules will be diſtributed betwixt thoſe of the ſulphur, and will adhere to it; the mixture will acquire a color more and more brown, or blackiſh, which is a certain ſign of the diviſion of the mercury; in a word, the mercury diſappears entirely, becauſe it is extinguiſhed and incorporated with the ſulphur. When the ſulphur has thus abſorbed all the mercury which it can receive in this method, the mixture is called *ethiops mineral*, from its black color.

The ſame combination may be made by fuſion, that is, by mixing the proper quantity of mercury with melted ſulphur. Theſe two ſubſtances unite together, as when triturated, and form a black compound, called *ethiops made by fire.* By this method the union of the ſulphur and of the mercury is made much more quickly, and ſomewhat more intimately. *See* Ethiops Mineral.

When mercury and ſulphur have been united together only by fuſion or trituration, the union is not ſufficiently ſtrong, nor the proportions ſuitable for making the moſt perfect and moſt intimate combination, called *cinnabar*;

for the preparation of which, ſublimation is neceſſary. By ſublimation of the ethiops, the mercury and ſulphur are raiſed together, and are more intimately combined. But we muſt obſerve, that in this ſublimation a part of the ſulphur of the ethiops, which is ſuperabundant to the combination of cinnabar, is ſeparated; ſo that only one part of ſulphur remains united in the cinnabar with ſix parts of mercury. This ſuperabundant ſulphur is not entirely ſeparated by one ſublimation. The ſublimation muſt then be repeated ſeveral times, that the cinnabar may be entirely free from the ſuperabundant ſulphur. The ſublimate, which is at firſt black like ethiops, becomes more and more red, as the mercury and ſulphur approximate more and more to their proper proportions; and laſtly, it remains in form of a very weighty, deep-red, ſtriated maſs, when the cinnabar is perfect. The red color of the cinnabar is ſo deep, becauſe the matter is exceedingly denſe; for when it is finely powdered, it acquires a fiery red color, and is then called *vermillion*, which is uſed in painting.

This combination of mercury with ſulphur is found native, and is called *native cinnabar*, to diſtinguiſh it from that made by art. Native cinnabar is mercury mineraliſed, or the ore of mercury. *See* ORES.

The connexion of mercury and ſulphur is ſo ſtrong in cinnabar, that the principles of this compound are not diſunited merely by the action of the fire, without burning the ſulphur. Thus cinnabar expoſed to fire in cloſe veſſels does only ſublime, without any decompoſition or alteration. To decompoſe, therefore, cinnabar, and to ſeparate the mercury from it, ſome intermediate ſubſtance muſt be employed, which has greater affininity than mercury with ſulphur. Theſe intermediate ſubſtances are calcareous earths, fixed alkalis, iron, copper, lead, ſilver, and regulus of antimony. If, then, cinnabar be mixed with any of theſe ſubſtances, and be diſtilled, the mercury will diſengage itſelf and paſs into the receiver, where it will appear in its proper fluid form; and the ſulphur will remain in the retort combined with the intermediate ſubſtance.

The mercury obtained in theſe operations is ſaid to be *revived from cinnabar*. It is juſtly conſidered as the pureſt, and fitteſt for chemical and medicinal purpoſes, and even for the arts in ſome caſes where very pure mercury is required.

The mercury obtained by the decompoſition of cinnabar is not only very pure, but the whole quantity which was in the cinnabar is thus obtained, when none of it is loſt in the operation; which proves that mercury ſuffers no alteration from the ſulphur. *See* CINNABAR.

Mercury, which, from what we have ſaid at the beginning of this article, is to be conſidered as a melted metal, alſo acts as ſuch with regard to all earthy and metallic matters. Like other melted metals, it cannot contract any union with earthy ſubſtances, not even with metallic earths; but it may be very well allayed with almoſt all metallic matters in the following order: Gold, ſilver, lead, tin, copper, zinc, regulus of antimony. Iron is not numbered amongſt the metals capable of uniting with mercury, becauſe no method has yet been diſcovered by which they can be united together.

The allays of mercury with metals are called *amalgams*, and are employed for many important purpoſes. The amalgams of gold and ſilver are employed for gilding and ſilvering, and for the extraction of theſe two metals from their ores; that of ſilver is employed for preparing the *arbor Dianæ*; that of tin for ſilvering looking-glaſſes, for mercurial balls, and for the preparation of the ſmoking ſpirit of Libavius. *See all theſe words, and the articles* ALLAY *and* AMALGAM.

All fat and oily matters, vegetable or animal, act upon mercury. If mercury be triturated with any greaſe, it ſuffers an alteration ſimilar to that in the preparation of ethiops by trituration. The parts of the mercury are thereby very much divided, and made to unite with thoſe of the greaſe. The mercury diſappears, is perfectly extinguiſhed, and acquires a black and leaden color. This combination of mercury and fat is called *mercurial ointment*, and is very uſeful in medicine; as we ſhall afterwards ſee.

The mercury in mercurial ointment muſt not be conſidered merely as diſtributed and intermixed with the parts of the fat: on the contrary, there is an adheſion and even intimate combination between the integrant parts of theſe two ſubſtances; for this fat very quickly becomes rancid, as all oily matters do when combined; and beſides, when mercurial ointment has been made a conſiderable time, all the mercury cannot be ſeparated from it even by fuſion. This fact has been verified by Mr. Beaumé.

Mercury, expoſed to the vapor of melted lead, or thrown into boiling linſeed oil, loſes its fluidity, and becomes ſo ſolid, that it may be formed into toys and ſmall utenſils. Although, properly ſpeaking, this is only an apparent fixation of mercury, ſince all its fluidity is reſtored to it by a little heat; this experiment proves, nevertheleſs, that ſome principle in theſe ſubſtances, probably their phlogiſton, is capable of acting ſenſibly upon mercury.

Perſons engaged in the diſcovery of the art of making gold, or of meliorating metals, conſidering that mercury has the metallic luſtre, and a gravity approaching to that of gold, have endeavored much to fix it; that is, to deprive it of its volatility and fluidity, intending always to give it the color of gold afterwards by a philoſophical tincture. The falſe fixations of mercury above-mentioned ſeem to indicate, that if any method by which mercury could be fixed were diſcovered, which is not very probable, this method muſt conſiſt in giving it ſome principle that it wants. Nevertheleſs, all the properties of mercury ſeem to ſhew, on the other ſide, that its fuſibility and volatility depend on ſome metallic principle united with it ſuperabundantly; and, conſequently, that its fixation ought rather to be effected by depriving it of ſome principle, than by any addition. However, we are certain that it muſt be effected by the one or the other, or by both theſe cauſes united. (*x*)

(*x*) The *purification of mercury* from extraneous ſubſtances is important for the purpoſes of medicine and of the arts, and eſpecially for ſome nice chemical operations. Mercury may be cleanſed from duſt, by ſtraining it through ſhamoy leather; from greaſe, by waſhing it with an alkaline lixivium; from any alkaline matter, by vinegar; from lead, or biſmuth, with which it is frequently adulterated, by diſtillation; from ſulphur, by mixing it with quicklime or with filings of iron, and then diſtilling the mixture. The beſt method of purifying mercury is by reducing it into ethiops mineral, with which twice the quantity of quicklime or of filings of iron is to be mixed; and by diſtilling it from this mixture. Its purity may be known, by obſerving that it does not ſoil clean white paper; that it has no pellicle on its ſurface; that when triturated

with

Mercury is one of the metals which beſt deſerves to be well known, not only from its great importance to chemiſtry and to the arts, but alſo from the powerful remedies it furniſhes againſt diſeaſes incurable by other means, particularly thoſe called venereal diſeaſes. The medicinal uſe of mercury has been known only ſince the introduction of thoſe diſeaſes into Europe. The ancient phyſicians did not uſe it, but conſidered it as a poiſon. This opinion ſeems to have been founded upon ſome accidents from mercury ill prepared, or given improperly, or perhaps from the tremblings and diſeaſes to which artiſts who handle mercury much are ſubject. However that may be, the Arabian phyſicians were the firſt who ventured to uſe mercury medicinally, and they employed it ſucceſsfully againſt the itch, and other diſeaſes of the ſkin.

When the venereal diſeaſe firſt appeared in Europe, in the army of Charles VIII. at the ſiege of Naples, a phyſician, called Beranger de Carpi, conſidering that the new diſeaſe diſcovered itſelf by cutaneous puſtules, ſimilar to thoſe of malignant itches, and encouraged by the example of the Arabians, attempted the cure by mercury, and ſucceeded. Nearly about this time, chemiſts and alchemiſts directed much of their labors towards medicine, and diſcovered many chemical remedies, the beſt of which are preſerved, and employed at this time with ſucceſs. The famous Paracelſus chiefly diſtinguiſhed himſelf in this way,

with water, it does not ſoil the water; that when expoſed to fire in an iron ſpoon or laddle, it does not crackle; and, laſtly, that it is perfectly and entirely ſoluble in pure ſpirit of nitre, without any depoſition.

Mercury may be united with all metallic ſubſtances, excepting iron, arſenic, and the ſemi-metal called nickel. *See a note under the article* Iron. Dr. Lewis obſerves, that in ſome caſes mercury abſorbs gold and ſilver from their ſolutions in acid and in alkaline liquors. This it may do by precipitating theſe metals, from its greater affinity to thoſe menſtruums, and by uniting or amalgamating with the very minute particles thus precipitated.

The mercury of an amalgam expoſed to heat, raiſes along with it ſome of the amalgamated metal, even of gold, as happens in the gilding of metals by amalgamation. Mere diſtillation, therefore, may not be ſufficient to procure mercury perfectly pure from metals. By the above-mentioned method of mixing it with ſulphur ſo as to form an ethiops, and afterwards with quicklime, and by diſtilling the mercury from that mixture, it may be obtained well purified from metals, which will remain engaged in the ſulphur, or rather liver of ſulphur, formed by the ſulphur and quicklime. By no method can purer and brighter mercury be obtained than by diſtilling it from cinnabar, by intervention of filings of pure iron. In all diſtillations of mercury, the addition of filings of iron ſeems to render the mercury more fluid and bright; probably by giving phlogiſton.

The *volatility of mercury may be diminiſhed* by ſeveral methods; ſome of which we ſhall mention. 1. Mercury calcined by heat, called the precipitate *per ſe*, ſuſtains during ſome time a red heat, and by expoſure to the heat of a burning glaſs is vitrifiable. 2. Dr. Brandt relates a very curious experiment, from which mercury appears capable of being ſo detained and fixed by digeſtion with gold, that a conſiderable part of it cannot be ſeparated from this metal by the moſt intenſe heat. 3. Mercury may be rendered conſiderably leſs volatile by being combined with vitriolic acid, but eſpecially with the vitriol of ſilver, or the ſalt formed by ſilver and vitriolic acid. This ſalt may be united with a conſiderable portion of mercury, with which it forms a concrete ſubſtance fuſible by fire, but capable of ſuſtaining, according to Dr. Lewis, the greateſt heat that can be applied to glaſs veſſels, without diſſipation of the mercury. 4. Neuman ſays, that if mercury ſublimate be frequently ſublimed with ſal ammoniac, and each time the ſublimed matter mixed with the reſiduum, the whole becomes at laſt ſo fixed in the fire, that it cannot be any more ſublimed.

and treated venereal diſeaſes with aſtoniſhing ſucceſs, by internal remedies, in form of pills. Although he has not publiſhed his remedies, it is believed from their effect, that the baſis of them was *turbith mineral.* Since that time mercury has been uſed in a great variety of forms.

Crude and fluid mercury taken internally produces no effect in the body; becauſe the adheſion of its integrant parts to each other hinders their diviſion, and diſtribution, or ſolution, without which it cannot have any effect. In its crude ſtate, therefore, it does nothing but load the ſtomach and inteſtines. It falls downwards by its weight, and goes out of the body along with the feces in the ſame ſtate in which it entered

Several phyſicians have believed that mercury, ſwallowed in its crude ſtate, may be uſeful in the iliac paſſion, imagining, that by its weight it is capable of reducing the inteſtines to their proper ſituation. But the effects are not ſuitable to their expectations. We have even ſeen this diſeaſe rendered worſe by mercury, from the ſhooting pains it occaſioned in theſe parts, already pained and irritated by ſpaſms. The uſe of crude mercury is now aboliſhed in theſe diſeaſes.

But when mercury is much divided, ſo that its molecules cannot again unite and form fluid mercury, in whatever manner this diviſion may have been made, it then produces very ſtriking effects, and ſuch as may be expected from the moſt powerful remedies.

Mercury adminiſtered in this ſtate accelerates the pulſe, divides and carries off the thickened humors, augments in general all excretions and ſecretions, but ſome preferably to others, according to circumſtances. If it be in a ſaline ſtate, or capable of being eaſily put into one, and be thus introduced into the body by the ſtomach in ſufficient quantity, it acts as an evacuant, purgative, or emetic. Mercurial frictions and fumigations chiefly encreaſe the ſecretion of ſaliva, and this in proportion to the quantity and number of doſes. Mercury, in every form, if ſufficiently divided, cures diſeaſes; and every preparation has its peculiar advantages and diſadvantages, which render it more or leſs adapted to particular circumſtances. We ſhall here mention the effects of the ordinary preparations of mercury.

Mercury precipitated *per ſe*, being much divided, is capable of entering the blood-veſſels; and when given in doſes from two to ſix grains, properly repeated, produces ſalutary effects in venereal diſeaſes. Notwithſtanding that it contains no ſaline matter, it is frequently purgative and even emetic, and is then leſs diſpoſed to ſalivate. But we muſt obſerve, that this preparation is a mercury exceedingly divided; that every body in this ſtate, and mercury perhaps more than any other, is diſpoſed to be attacked by every ſolvent; that it meets in the primæ viæ ſeveral ſubſtances, even of the ſaline kind, which are capable of diſſolving it; and that then it muſt produce the effects of a ſaline mercurial combination, which effects are in general purgative or emetic. Theſe properties of the precipitate *per ſe* ſhew, that it may be ſucceſsfully employed in many caſes. Nevertheleſs, this preparation is not much uſed, perhaps becauſe it is very dear.

The combination of mercury with a ſufficient quantity of vitriolic acid, to render it ſoluble in water, is very corroſive, and therefore not given internally.

Turbith mineral taken internally produces nearly the ſame effects, and in the ſame doſes as the precipitate *per ſe*, and undoubtedly for the ſame reaſon; for if it retains a little vitriolic acid, as moſt chemiſts have believed, this ſmall quantity of acid ſeems to be ſufficient to make it act as a ſaline mercurial combination: and if, on the contrary, when it is perfectly waſhed, no acid remains, it will be entirely ſimilar to the precipitate *per ſe*, and, like this precipitate, will be diſpoſed to receive a ſaline ſtate, and to act in the ſame manner. Turbith mineral has been much commended, and is ſtill uſed by ſome perſons in venereal diſeaſes.

All the precipitates of mercury, when ſeparated from any acid by an alkali, and afterwards edulcorated, ought to produce internally the ſame effects as the precipitate *per ſe*, and as turbith mineral, ſuppoſing it to be freed from all acid by lotions. Thus the great number of ſuch mercurial preparations nearly equivalent to each other, are but little uſed, which muſt be attributed to the want of attention to their nature and advantages.

The ſolution of mercury in the nitrous acid, and mercurial nitre, are juſtly ranked amongſt corroſives.

Some perſons, and Lemery amongſt others, ſay, that they may be taken internally if they are diluted; an ounce of ſolution, for example, with 24 ounces of water or ptiſan. This is called *mercurial water*.

Lemery ſays, that from half an ounce to an ounce of this mercurial water may be taken in a glaſs of ptiſan, or broth, and that it vomits gently, and excites ſalivation. Mr. Baron, in his notes on Lemery, juſtly exclaims againſt the uſe of that dangerous remedy. Nevertheleſs phyſicians of great reputation have introduced, and even ſucceſsfully, the uſe of corroſive ſublimate for the cure of venereal diſeaſes, although this preparation is no leſs corroſive than the ſolution of mercury in nitrous acid.

A pomatum is made of two ounces of mercury diſſolved in a ſufficient quantity of nitrous acid, and mixed perfectly well in a mortar with two pounds of hog's-lard. This pomatum admirably cures the itch. The ſolution of mercury acts powerfully upon the hogs lard with which it combines, and to which it gives greater ſolidity, while at the ſame time it is itſelf rendered thereby much milder. The pomatum is of a citron color, and is to be lightly rubbed upon the parts attacked by the itch, which by this treatment ſoon diſappears. This pomatum for the itch comes from the Hotel-Dieu at Paris, where it is given to convaleſcents, by which they are quickly cured of the itch, which they all catch by remaining ſome time in the hoſpital. The receipt of this pomatum is alſo found in the laſt edition of the Diſpenſatory at Paris.

Red precipitate is not uſed internally, but is employed externally as a detergent and cicatriſing eſcharotic, in the treatment of venereal ulcers.

All the combinations of mercury with marine acid are uſed. Of theſe the corroſive ſublimate has been the leaſt uſed, in France at leaſt. The terrible accidents and deaths occaſioned by ſmall doſes of this preparation have confined its uſe to external application, as an eſcharotic; and even then it is generally rendered milder, or rather decompoſed by mixture with quicklime. But ſome years ago Van Swieten, a diſciple of Boerhaave, and principal phyſician to the Empreſs-Queen, introduced the internal uſe of corroſive ſublimate for the venereal diſeaſe. This great phyſician diſſolved twelve grains of ſublimate in two pounds of malt ſpirits, and gave this ſolution by ſpoonfuls, diluted copiouſly with emollient liquors.

A great number of trials made by Van Swieten and many others of the profeſſion have proved, beyond any poſſibility of doubt, that corroſive ſublimate, adminiſtered in this manner, is a powerful anti-venereal, capable of curing inveterate poxes, which have reſiſted the other ordinary preparations of mercury. We know beſides, that the internal uſe of corroſive ſublimate has been long eſtabliſhed amongſt the Tartars and amongſt the Ruſſians, whoſe unreſtrained manner of living with all ſorts of women expoſes them to a continual accumulation of venereal diſeaſes.

But notwithſtanding theſe powerful motives to confide in this remedy, many excellent phyſicians are ſtill deterred from the uſe of it. They obſerve, that the uſe of corroſive ſublimate ſeems only to agree with cold climates, and they believe that it always has diſagreeable conſequences in ſuch as are hot or temperate. They think that a number of compleat cures, without any ſeeming inconveniencies, do not juſtify the uſe of a ſubſtance which is ſo corroſive, that very bad conſequences may be apprehended from it, when it has been once introduced into the body.

Opinions therefore are ſtill divided upon the internal uſe of corroſive ſublimate. Time and experience muſt decide concerning them. But this is certain, that a remedy of this kind cannot be adminiſtered with too much caution, prudence, and diſcernment; that every one ought not to pretend to meddle with it; and that this, and moſt other very active ſubſtances, are kinds of poiſons, and only become powerful remedies in the hands of able phyſicians.

If it were once eſtabliſhed, that corroſive ſublimate given internally cures venereal diſeaſes radically, and without troubleſome conſequences, we ſhould think it certain, that the ſaline combinations of mercury with the other acids may be employed as ſafely for the ſame purpoſes; that is, the vitriolic and nitrous mercurial ſalts; for theſe ſalts are not more, perhaps leſs, cauſtic than corroſive ſublimate: and beſides, the vitriolic and nitrous acids being more diſpoſed to unite with oily matters than the marine acid, they are therefore more ſuſceptible of being rendered milder within the body than the corroſive ſublimate, which ought therefore to be conſidered as the moſt dangerous of all that are uſed in medicine.

Sweet mercury, not being corroſive, may certainly be uſed internally, and has been ſo a long time. But notwithſtanding the great quantity of mercury with which the marine acid in this compound is charged, it ſtill retains ſenſibly a ſaline quality, and is purgative, when taken from four grains to 15 or 18. It is uſed in the treatment of venereal diſeaſes, particularly when it is intended to purge. But it is not uſual to attempt the cure of a true pox by this remedy only. The *mercurial panacea*, which is only apparently ſaline, acts, when taken internally, ſimply as mercury deprived of its fluidity, but too little divided to acquire a ſaline quality in the alimentary canal: accordingly it does not generally purge, but rather ſalivate, when given in a large enough quantity. The doſe of it is from ten grains to twenty-four or thirty. It is to be repeated as occaſion requires, and at proper intervals. Several perſons of the profeſſion cure the pox by this remedy only.

White precipitate, however it be made, is much more ſaline than ſweet mercury. Accordingly it excites vomiting, and muſt be given more cautiouſly and in leſs quantity; but it is little uſed. Neverthelefs, if the propriety of uſing corroſive ſublimate were eſtabliſhed, this precipitate may alſo be advantageouſly employed with proper management. It would probably produce the ſame effects in a larger doſe.

No ſenſible effect is produced by the combinations of mercury with ſulphur, whether *ethiops* or *cinnabar*, taken internally, and in large doſes. Some phyſicians therefore reject theſe mercurial preparations as uſeleſs and inactive. This is certain, that mercury united with ſulphur has no ſaline quality, and is very little acted upon by menſtruums, becauſe it is defended by the ſulphur, nearly as the regulus of antimony is in antimony. Cinnabar is uſed nevertheleſs in venereal diſeaſes, and ſucceſsfully on certain occaſions, and then it is decompoſed by burning. The body of the patient is expoſed to the vapors of mercury, which are diſengaged by this burning. Theſe mercurial vapors inſinuate themſelves through the pores of the ſkin, excite ſalivation, and cure the venereal diſeaſe. This is called *the method by fumigation*.

We know yet very little the effects which are produced by combinations of mercury with vegetable acids, if it be true that Keyſer's pills have for their baſis the acetous mercurial ſalt, as is very probable. We may nevertheleſs ſuppoſe that mercury adminiſtered in this form might produce good effects.

Laſtly, of all the preparations of mercury, the moſt generally employed is certainly that called *mercurial ointment*. It is, as we mentioned above, mercury extinguiſhed by trituration with fat. The only method of uſing this ointment is by rubbing it on the body of the patient, and repeating this friction at proper intervals and in proper doſes, till a ſufficient quantity of mercury has been introduced to effect a cure. This is called *the method of friction*.

This method is more prevalent than the others. It is recommended by the beſt phyſicians, and particularly by the learned Aſtruc. The chief motives for this preference are, that mercury introduced by this method has no corroſive quality, and that as much of it as is neceſſary for the cure may be thus introduced without inconvenience.

Mercury adminiſtered by friction or by fumigation produces no purgative or emetic effect, becauſe it does not enter into the body by digeſtion, but is immediately introduced into the lymphatic and blood veſſels. There it circulates, and penetrates into their moſt remote receſſes. When ſufficient doſes of it are given, it produces almoſt always a ſalivation more or leſs ſtrong, makes the ſymptoms diſappear, and ſubdues at length the venereal poiſon.

This is all that we know concerning the effects produced by mercury. The nature of this poiſon, and the preciſe manner of the action of the mercury, are ſtill unknown. Many phyſicians believe, that, as mercury is capable of a diviſion into very minute but weighty globules, theſe globules act mechanically by their number and by their weight upon the lymph, which they ſuppoſed to be thickened and coagulated by the venereal poiſon, and which by this action of the mercury was attenuated, divided, and reſtored to its ordinary ſtate. But this opinion, although one of the moſt ſpecious that has appeared upon the ſubject, is nevertheleſs far from the truth; for if this opinion were juſt, mercury could only, while it was fluid and in its proper ſtate, cure the venereal diſeaſe. But experience has proved inconteſtably, that mercury in a ſaline ſtate, ſuch as it is in corroſive ſublimate, and conſequently deprived of all the properties of ordinary mercury, cures the pox effectually, and particularly in a doſe infinitely leſs than when it is adminiſtered by friction or fumigation.

Hitherto it ſeems to have been believed, that mercury in the mercurial ointment is only divided, diſperſed, and interpoſed betwixt the parts of the fat, without being truly diſſolved and combined; and this undoubtedly has given cauſe to the above-mentioned opnion. We are nevertheleſs certain, that much of the mercury contained in the ointment is really combined either with the acid, or with the whole ſubſtance of the fat. This being eſtabliſhed, may we not conclude, that mercury cannot cure the venereal diſeaſe but when it is really diſſolved, and deprived of its properties of fluid mercury; that only the portion of mercury in the ointment, which is thus combined, affects the cure, and that the other portion of the mercury which remains in its natural ſtate in the ointment (for much of the mercury is in this ſtate) paſſes into the body without producing any effect; for which reaſon the mercurial ſalts cure in much leſs doſes than the mercurial ointment; that, laſtly, if the portion of mercury introduced into the body in its proper ſtate by friction or fumigation contributes to the cure, the reaſon of it is, that the moſt divided part of this mercury unites within the body with ſome greaſy or other ſubſtance with which it is capable of combining?

If this be true, ought we not to ſearch for ſome new combination of mercury, which ſhall be at the ſame time very ſoluble and free from cauſticity? Such a remedy would certainly be very precious. For although the mercury of the mercurial ointment is not cauſtic, and although the method by friction is undoubtedly the moſt advantageous and certain, it is not however free from inconveniencies. It frequently expoſes to dangerous ſalivations, accompanied with very troubleſome accidents; and if to avoid them, the quantity of ointment be diminiſhed, and the intervals of the ſeveral frictions lengthened, by which indeed theſe accidents are avoided, the cure then is not only of a tedious length, but is alſo ſometimes imperfect, or leſs certain.

But have we reaſon to flatter ourſelves with the hopes of finding ſuch a preparation of mercury? If we conſider that mercury has been tried in a great variety of methods, and by very able chemiſts, and that, notwithſtanding, no preparation has yet been found free from inconveniencies, we ſhall be apt to deſpair of ſucceſs in this inquiry. But on the other ſide, if we reflect on the nature and properties of mercury; if we conſider that this ſingular ſubſtance, as we have ſeen in the preſent article, is perhaps one of thoſe which may be combined in the greateſt variety of manners; that it is acted upon by almoſt every ſolvent; we may ſtill have hopes of finding a mercurial preparation, not only much ſuperior to thoſe hitherto known, but which perhaps ſhall be attended with no inconvenience.

The uſe of mercury is not confined to the venereal diſeaſe. We have already ſeen, that its antivenereal quality was diſcovered from its property of curing the itch, even the moſt malignant; and, in fact, it does cure much more readily and efficaciouſly than any other remedy, not only the ſeveral kinds of the itch, but alſo many other cutaneous diſeaſes more or leſs ſimilar to the itch, and which are very various.

Another medicinal quality of mercury is, that of deſtroying the worms and inſects of all kinds which are apt to infeſt the human body, either internally or externally. In the cure of theſe two latter kinds of diſeaſes, the ſame preparations of mercury, but ſmaller quantities, are employed as for the venereal diſeaſe.

Laſtly, ſome obſervations made lately by able phyſicians ſeem to give hopes, that by mercury another ſcourge more terrible, but fortunately leſs frequent, than thoſe diſeaſes above-mentioned, namely, the madneſs occaſioned by the bite of a mad dog, may be cured. But this effect of mercury is not ſufficiently eſtabliſhed, and requires to be confirmed by many new obſervations, which would require a conſiderable time, ſince happily the occaſions of trying them are not very frequent.

Phyſicians, ſtruck with the ſurprizing ſucceſs of mercury in certain very obſtinate and otherwiſe incurable diſeaſes, were induced to try it in moſt of the other diſeaſes which were incurable by the ordinary remedies; and particularly in thoſe which were attributed, as well as the venereal diſeaſe, to a thickneſs or coagulation of lymph, ſuch as the ſcrophula, cancers, ſchirrhus, and others of this kind. But mercury was not found to have any good effect in theſe diſeaſes; and ſome diſeaſes, ſuch as the ſcurvy, the ſymptoms of which are ſo like thoſe of the pox that they cannot eaſily be diſtinguiſhed, were not only not diminiſhed, but aggravated by mercury.

We may ſtill however hope, that ſo powerful a remedy may be employed ſucceſsfully in other diſeaſes Perhaps for this purpoſe only ſome new method of preparing it is wanting. But even at preſent, it is one of our moſt valuable remedies.

CCCCXLV. MERCURY (ANIMATED). This is mercury purified by alchemical proceſſes, for the preparation of the philoſopher's ſtone.

CCCCXLVI. MERCURY (SWEET). Sweet mercury, called alſo *aquila alba*, is corroſive ſublimate combined by further operations with all the mercury which it can receive, and afterwards ſublimed thrice.

To make ſweet mercury, corroſive ſublimate is to be triturated carefully in a glaſs mortar with fluid mercury, which is to be added gradually as it diſappears. This is to be continued till the corroſive ſublimate is ſaturated and will receive no more mercury, which is known by the globules not diſappearing by trituration. Lemery ſays, that corroſive ſublimate can only receive about three quarters of its weight of freſh mercury; nevertheleſs a larger quantity, a half, may without inconvenience be added, becauſe thereby the corroſive ſublimate will be more perfectly edulcorated, and the ſuperabundant mercury will be eaſily diſengaged; as we ſhall ſoon ſee.

The corroſive ſublimate receives from the mercury with which it is triturated a blackiſh-grey color, which color mercury always acquires when it is much divided, and ſtill retains its metallic ſtate. This grey matter is to be put into one or more matraſſes with ſhort necks, or rather into the veſſels called medical phials, ſo that two-thirds of the containing veſſel ſhall be empty for the ſake of the ſublimation.

Theſe matraſſes are to be placed in a ſand-bath, and ſunk in ſand to the height of the contained matter. The fire is then to be gradually augmented till we ſee that the ſublimation begins. It is then to be kept in this ſtate till it be all ſublimed, and attached to the top of the veſſel, excepting a ſmall portion of fixed matter which remains at the bottom. When the matraſſes are cold, they are to be carefully broken. The white compact ſublimate is to be ſeparated from ſome leſs white and denſe adhering to the neck of the veſſel, to be again powdered, and ſublimed a ſecond and a third time in the ſame manner, always taking care to ſeparate each time the compact white maſs from that part which has leſs of theſe qualities. The ſweet mercury is then in its moſt perfect ſtate; a white, heavy, ſemitranſparent maſs, ſmooth as glaſs in its convex part, where it adhered to the veſſel.

In theſe operations no mortars muſt be employed, upon which the acid or the mercury of the corroſive ſublimate can act: therefore neither marble nor metal mortars are proper, but thoſe made of glaſs.

Although the crude mercury which is triturated with the corroſive ſublimate is joined to it ſuperabundantly, and contracts with it a certain degree of union, this union is not nearly ſo intimate as it may be, and as it is after the perfect dulcification of the corroſive ſublimate; for if we take internally corroſive ſublimate impregnated by trituration alone, with all the crude mercury which it can perfectly extinguiſh, it would produce nevertheleſs very violent corroſive effects. By ſublimation then the new mercury is completely combined with the acid of corroſive ſublimate, which is thus rendered milder. The external mark of this intimate combination is the change of color from an opake grey, which the matter had before ſublimation, to a tranſparent white, which it afterwards acquires. This opake grey color proceeds, as we ſaid, from the mercury preſerving its metallic ſtate, which it does becauſe it is not intimately enough combined with the acid; and the white, tranſparent, ſaline appearance is a certain ſign of this intimate combination.

One or two ſublimations are not ſufficient to change entirely the corroſive ſublimate into ſweet mercury; experience ſhews that three ſublimations are neceſſary. The mercurial ſublimate may then be taken internally without danger. It is no longer corroſive, nor retains any more of its ſaline property than is ſufficient to render it purgative in a doſe from four or five to twenty-four or thirty grains: and if ſweet mercury be ſublimed eight or nine times, or perhaps leſs, it loſes its purgative quality, and is then called MERCURIAL PANACEA. *See* PANACEA.

The matter which adheres to the neck of the retort, particularly in the firſt ſublimations, is an imperfect combination of crude mercury with corroſive ſublimate, and muſt therefore be ſeparated from the reſt of the maſs. When the quantity of crude mercury triturated with corroſive ſublimate is more than can be united with it into ſweet mercury, the ſuperabundant mercury remains in its metallic ſtate, and gives a grey or blackiſh color to the ſweet mercury. This ſuperabundant mercury may be diſengaged by ſubliming in a retort, as Stahl propoſes, and as Mr. Baron remarks in his Notes on Lemery.

The fixed matter which remains at the bottom of the matraſs is quite extraneous to the mercurial ſublimate. It is a portion of earthy ſubſtances proceeding from the ſalts employed in the preparation of corroſive ſublimate, and which this ſublimate had carried along with it in ſublimation. For, in general, volatile bodies are capable of carrying along with them a part of the fixed bodies with which they happen to be mixed, particularly when they are expoſed to a ſtronger heat than is neceſſary for their ſublimation. For this purpoſe no union betwixt the fixed and the volatile bodies is neceſſary. This is done by a purely mechanical impulſion of the volatile parts againſt the parts of the fixed body. Hence the heavieſt volatile bodies muſt produce this effect more ſenſibly than thoſe which are lighter. Accordingly, the ſublimates of mercury, which are certainly the heavieſt of all volatile bodies, produce this effect ſurprizingly. For in the operation for ſweet mercury, ſometimes fragments of the matraſſes in which the ſublimation had been made, and which adhere to the matter which is again to be ſublimed, are raiſed along with the mercurial ſublimate. Mr. Beaumé has frequently found large fragments of glaſs in the middle of maſſes of the ſublimates, which had been made in great works, where the ſame care and attention are not given as in the ſmall operations of chemical laboratories.

Lemery remarks, that ſweet mercury acquires a yellowiſh color when it is triturated. This color proceeds from the quantity of mercury being conſiderable with reſpect to the acid; for that is the ordinary color of mercury when it is much divided, and has not its metallic luſtre, as we ſee from the example of the precipitate *per ſe*, of turbith mineral, and other preparations of mercury which are in this ſtate. *See* MERCURY, *and* SUBLIMATE (CORROSIVE).

CCCCXLVII. MERCURY *of* PHILOSOPHERS. Alchemiſts have given the name of mercury to many other things beſides the metallic ſubſtance generally ſo called. This latter they call ordinary mercury, and value it little. We cannot preciſely ſay what they meant by their mercury, from the obſcurity of their writings, and alſo from their different deſcriptions of the matter. No term is more frequently uſed by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the ſame idea annexed to the term *philoſophical mercury*. The moſt probable opinion upon this ſubject is, that this mercury is the metallic principle which Beccher has called *mercurial earth*. *See* EARTH (MERCURIAL), *and the following article*.

CCCCXLVIII. MERCURIFICATION. Mercurification is an alchemical operation, by which metals are ſaid to be reduced into a fluid, heavy, opake, and ſhining liquor, like ordinary mercury; or by which the mercurial principle may be extracted from metals, and obtained in the form of quickſilver. But, theſe mercurified metals, or their mercurial principle rendered ſenſible, are a kind of philoſophical mercury, which, although they reſemble ordinary mercury, are nevertheleſs ſaid, by perſons exerciſed in ſuch ſtudies, to differ from it conſiderably, by having a greater ſpecific gravity, by more effectually penetrating and diſſolving metals, by a ſtronger adheſion to theſe, and by a leſs volatility.

We may find in the books of many authors, who, though not alchemiſts, give more or leſs attention to theſe ſubjects, a great number of proceſſes for mercurification, or for obtaining the mercury of metals; moſt of which are very long, laborious, confuſed, and conſequently ſubject to fail. The detail of theſe proceſſes would be too long. An account of the principal of theſe operations may be ſeen in *Junker's Conſpectus Chemiæ*. We ſhall only mention ſome of the eaſieſt mercurifications, extracted from the moſt modern authors, as *Wallerius* and *Teichmeyert*.

If cinnabar of antimony made with corroſive ſublimate be diſtilled, we ſhall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corroſive ſublimate.

If a corroſive ſublimate be prepared with ſpirit of ſalt and fluid mercury, and if calx or filings of ſilver be ſeveral times ſublimed together with this corroſive ſublimate, a part of the ſilver will be changed into mercury.

Very fine filings of iron, expoſed during a year to the air, and afterwards well triturated in a mortar, and cleanſed from duſt and extraneous matter, then expoſed during another year to the air, and, laſtly, diſtilled in a retort, furniſhes a hard matter which attaches itſelf to the neck of the retort, and with this matter a little mercury. *Teichmeyert.*

If calx of copper be mixed with ſal ammoniac, and this mixture expoſed during a certain time to air, and diſtilled with ſoap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated ſpirit of ſalt, digeſted together during three or four weeks, then an equal quantity of black flux and Venice ſoap added to it, and the whole matter diſtilled in a glaſs retort, ſome mercury will paſs into the receiver.

Theſe experiments are important and eaſily made, but have not been repeated by modern chemiſts; for which we ſee no other reaſon than the ſmall hopes of their ſucceeding. If they ſhould ſucceed, they would aſcertain the exiſtence of a mercurial principle in metals, and would ſo much more confirm the theory of Beccher, as all the experiments above-mentioned are made with the marine acid, which that chemiſt ſuppoſes to contain the mercurial earth. The concluſion deducible from theſe experiments would be, that, by introducing a ſuperabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. *See* METALS.

Many other proceſſes for mercurification may be ſeen in authors who have treated of this matter, particularly in Junker's book above quoted, in which marine acid is not employed, but other ſaline matters, or ſublimation through the burning fuel, with concourſe of free air, in Geber's manner. In this latter caſe, we muſt look for the mercurial ſubſtance in the metallic fumes and flowers; and if any ſuch ſubſtance be obtained, it muſt evidently proceed from the decompoſition of the metallic matter employed.

Mr. Groſſe ſays, in the Memoirs of the Academy, that he obtained mercury from lead by an eaſier and ſimpler proceſs than thoſe above-mentioned. This conſiſts in ſaturating perfectly ſome good nitrous acid with lead, which may be done effectually by employing more lead than the acid can diſſolve; and from this ſolution, according to Mr. Groſſe, a grey powder is precipitated, in which mercury is diſcovered. This experiment being ſhort, Meſſrs. Macquer and Beaumé repeated it with due attention in their Courſe of Chemiſtry; but they did not find the grey mercurial powder mentioned by Mr. Groſſe. As the exactneſs and veracity of that able chemiſt are well known, we muſt believe that the lead which he employed contained ſome extraneous mercury, which might eaſily happen in a laboratory. The ſame thing has poſſibly happened in other experiments of mercurification; and this proves how circumſpect we ought to be in drawing concluſions.

CCCCXLIX. METALS *and* METALLISATION. Under the general name *metal*, we comprehend here not only the metals properly ſo called, but alſo the ſemimetals, or all matters which have the eſſential metallic properties, which we ſhall here recount. Thus the word *metal* and *metallic ſubſtance* will be ſynonimous in this article.

Metallic ſubſtances form a claſs of bodies not very numerous, of very great importance in chemiſtry, medicine, arts, and the ordinary affairs of life. Theſe ſubſtances have very peculiar properties, by which they differ from all other bodies.

The natural bodies from which metals differ the leaſt are earthy and pyritous matters, on account of their ſolidity and denſity. Metals and ſtones are, nevertheleſs, very different, the heavieſt ſtones which are unmetallic being much lighter than the lighteſt metals. A cubic foot of marble weighs 252 pounds; and an equal bulk of tin, the lighteſt of metals, weighs 516 pounds. The difference is much greater when the weight of ſuch a ſtone is compared with that of gold, a cubic foot of which is 1326 pounds.

Opacity is another quality which metals poſſeſs eminently; the opacity of metals being much greater than the opacity of any unmetallic ſubſtance.

This great opacity of metals is a conſequence of their denſity, and theſe two properties produce a third, peculiar alſo to metals, namely, a capacity of reflecting infinitely more light than any other body: hence metals whoſe ſurfaces are poliſhed, form mirrors repreſenting the images of bodies, more clearly than any other matter. Thus looking-glaſſes produce their reflexion merely by the ſilvering, which is a covering of metal upon their ſurfaces. To this reflective property metals owe their peculiar luſtre, called the *metallic luſtre.*

Although the ſeveral metallic ſubſtances differ conſiderably in hardneſs and fuſibility, we may ſay in general, that they are leſs hard and leſs fuſible than pure earths.

Metals cannot unite with any earthy ſubſtance, not even with their own earths, when theſe are deprived of their metallic ſtate: hence when they are melted, they naturally run into globes, as much as the abſolute gravity of their maſs, and their preſſure upon the containing veſſels, will allow. Accordingly, the ſurface of a metal in fuſion is always convex. A metal in that ſtate always endeavors to acquire a ſpherical form, which it does more perfectly as the maſs is leſs. This effect is very ſenſible in quickſilver, which is nothing but a metal habitually fluid or fuſed. A maſs of ſeveral pounds of mercury, contained in a ſhallow, wide-mouthed veſſel, is ſo ſpread out, that its upper ſurface is almoſt flat, and the convexity is not very ſenſible but at its circumference: on the contrary, if we put very ſmall maſſes of mercury into the ſame veſſel, as, for inſtance, maſſes weighing a grain each, they become ſo round as to ſeem perfect globes. This effect is partly occaſioned by the inaptitude of metals to unite with the veſſels containing them when in fuſion; by which quality the whole affinity which ſubſiſts betwixt the integrant parts of theſe metals is capable of acting; and partly alſo by this affinity, which diſpoſes the integrant parts to come as near to each other as they can, and conſequently to form a ſphere.

This property is not peculiar to melted metals, but to all fluids, when contiguous to bodies ſolid or fluid, with which they have no tendency to unite. Thus, for inſtance, maſſes of water upon oily bodies, or oily maſſes upon bodies moiſtened with water, aſſume always a form ſo much nearer to the ſpherical as they are ſmaller. Even a large drop of oil poured upon a watery liquor, ſo that it ſhall be ſurrounded with this liquor, becomes a perfect ſphere.

All metals are in general ſoluble by all acids; but often theſe ſolutions require particular treatment and circumſtances, which are mentioned under the articles of the ſeveral metals. With acids, they form neutral ſalts with metallic baſes. Theſe ſalts have all more or leſs cauſticity, which proceeds from the little intimacy of union betwixt the acid and metal, and from the great weight of the latter ſubſtance. The affinity of metals is leſs than of abſorbent earths and alkaline ſalts to acids; and therefore any metal may be ſeparated from any acid by theſe earthy and ſaline alkalis.

Alkaline ſalts are capable of acting upon all metallic ſubſtances, and of keeping them diſſolved by proper management.

Metals may in general be united with ſulphur and liver of ſulphur. With ſulphur they form compounds reſembling the peculiar ſubſtance of ores, which are generally nothing elſe than natural combinations of ſulphur and metal. Metals have leſs affinity with ſulphur than with acids; hence ſulphur may be ſeparated from them by acids. Some exceptions from theſe general rules, concerning the affinity of metals to ſulphur and liver of ſulphur, and concerning their ſeparation from ſulphur by acids, may be ſeen under the articles of the ſeveral metals. But theſe exceptions do probably take place, only becauſe we have not yet found the method of ſurmounting ſome obſtacles which occur in the ordinary methods of treating certain metals.

All metals may in general be united with each other, with which they form different allays which have peculiar properties; but this rule alſo is not without ſome exceptions. *See* ALLAY *and* AMALGAM.

Metals have ſtrong affinity with the inflammable principle, and are capable of receiving it ſuperabundantly.

Laſtly, oily ſubſtances ſeem to be capable of acting upon all metals. Some metals are eaſily and copiouſly diſſolved by oils, and perhaps they might all be found to be entirely ſoluble in oils, if the methods known in chemiſtry were tried for the accompliſhment of theſe ſolutions.

The properties above-mentioned agree in general to all metallic ſubſtances: but, beſides the properties peculiar to each metal, ſome properties are common to a certain number of them; and hence they have been divided into ſeveral claſſes.

Thoſe metallic matters which, when ſtruck by a hammer, or ſtrongly compreſſed, are extended, lengthened, and flattened, without being broken, (which property is called *ductility* or *malleability*) and which alſo remain fixed in the moſt violent and long continued fire, without diminution of weight, or other ſenſible alteration, are called *perfect metals.* Theſe perfect metals are three; *gold*, *ſilver*, *platina.*

The metallic matters which are ductile and fixed in the fire, to a certain degree, but which are deſtroyed by the continued action of fire, that is, changed into an earth deprived of all the characteriſtic properties of metals, are called *imperfect metals.* Of this kind are four; *copper*, *iron*, *tin*, *lead.*

The metallic ſubſtances which, as well as the imperfect metals, loſe their metallic properties by expoſure to fire, but which alſo have no ductility nor fixity, are diſtinguiſhed from the others by the name of *ſemi-metals.* Of this claſs are five; *regulus of antimony*, *biſmuth*, *zinc*, *regulus of cobalt*, and *regulus of arſenic.*

Laſtly, mercury, which has all the general properties of metals, makes a claſs ſeparate from the others; becauſe in purity and gravity it is ſimilar to the perfect metals, and in volatility to the ſemi-metals. Its fuſibility alſo ſo far ſurpaſſes that of any other metallic matter, that it is ſufficient to diſtinguiſh it from all, and to give it a diſtinct claſs. We have enumerated, therefore, in all, thirteen metallic ſubſtances, two of which only were unknown to the ancients, namely, platina and regulus of cobalt. We have reaſon to wonder that theſe two metallic bodies, and particularly platina, which is a perfect metal, ſhould have remained unknown till lately.

This may give us cauſe to hope, that if natural hiſtory and chemiſtry be carefully cultivated, as they have been ſince the renovation of the ſciences, we may ſtill make eſſential diſcoveries in this way. Mr. Cronſtedt has given, in the Swediſh Memoirs, a deſcription of a metallic matter, which, as he ſays, appears to be a new ſemimetal diſtinct from the others. In that caſe, this would be the fourteenth metallic matter known, and the third lately diſcovered: but as, ſince the Memoir of Mr. Cronſtedt, this new ſemimetal has not been examined by chemiſts, it is yet but little known; and therefore further experiments ſeem requiſite to decide whether it ought to be admitted as a new ſemimetal. (y)

As chemiſts can only know compound bodies by being capable of ſeparating the principles of ſuch bodies, and even of re-uniting their principles ſo as to reproduce ſuch compounds as they were originally; and as hitherto they have not been able to accompliſh any ſuch decompoſition upon the perfect metals; hence, if all the other metallic ſubſtances were equally inalterable, we ſhould be very far from having certain notions concerning metals in general: but if we except gold, ſilver, and platina, all the other metallic matters are ſuſceptible of decompoſition and of recompoſition, at leaſt to a certain degree; and the experiments of this kind made by chemiſts, and chiefly by the modern chemiſts, have thrown much light on this important ſubject.

We may obſerve, that even if we had not been able to decompoſe any metallic ſubſtance, we might ſtill, by reflecting on the eſſential properties of metals, diſcover ſufficiently well the nature of their principles.

The ſolidity, the conſiſtence, and eſpecially the gravity which they poſſeſs in a degree ſo ſuperior to all other bodies, would not have allowed us to doubt that the earthy element, of which theſe are the characteriſtical properties, enters largely into their compoſition, and makes their baſis.

The facility with which they combine with almoſt all inflammable matters, and with all thoſe which have great affinity with phlogiſton, ſuch as acids; joined to their incapacity of being allayed with meagre matters that are purely earthy or purely watery, which have no diſpoſition to unite with phlogiſton; would alſo have furniſhed very ſtrong motives to believe, that the inflammable principle enters largely into the compoſition of metals.

We muſt acknowledge, however, that theſe conſiderations would only have furniſhed concerning the exiſtence of the inflammable principle in metals, but a ſimple probability, very far from the compleat proof we now have: but the combuſtibility of all metals capable of decompoſition by this method, and of a ſubſequent reduction with all their properties, by the rejunction of the inflammable principle, furniſhes the cleareſt and the moſt ſatisfactory demonſtration that we have in chemiſtry. We ſhall now mention what is known upon this ſubject, and the conſequences neceſſarily reſulting.

(y) See Nickel. Mr. *Juſti* pretends that he has diſcovered a new metallic ſubſtance contained in yellow mica. This he ſays was of a blackiſh-grey color; but when mixed with gold heightened the luſtre, without deſtroying the malleabity of that metal, though itſelf is brittle.

The deſtructible metals preſent exactly the ſame phenomena as all other bodies containing the inflammable principle do, in the ſtate of combuſtion. When expoſed to fire, without acceſs of air, that is, in cloſe veſſels, they become red-hot, melt, or ſublime, according to their nature: but they receive no alteration in their compoſition from fire applied in this manner, and they are afterwards found to be exactly in the ſame ſtate as before. In this reſpect, they reſemble perfectly all bodies which contain no other inflammable matter than pure phlogiſton.

But when imperfect metals are expoſed to fire, with acceſs of air, as, for inſtance, under a muffle in a furnace which is made very hot, then they burn more or leſs ſenſibly, as their inflammable principle is more or leſs abundant, or more or leſs combined. Some of them, as iron and zinc, burn with a very lively and brilliant flame; but this flame is of the ſame nature as that of charcoal, of ſulphur, of all bodies, the combuſtible principle of which is pure phlogiſton, and is not in an oily ſtate, that is, furniſhes no ſoot capable of blackening.

Alſo the imperfect metals detonate with nitre, when all the circumſtances which that detonation requires are united. *See* DETONATION *of* NITRE. Their phlogiſton is conſumed by this method much more quickly and compleatly than by ordinary calcination or combuſtion. Their flame is alſo much more lively and brilliant; and ſome of them, as iron and zinc, are uſed in compoſitions for fireworks, from their very vivid and beautiful flame.

Nitre is alkaliſed by theſe metallic detonations exactly in the ſame manner as in its detonation by coals.

Laſtly, imperfect metals being treated with acids which have an affinity with phlogiſton, that is, with the vitriolic and nitrous acids, are deprived alſo by theſe acids of a more or leſs conſiderable part of their inflammable principle: They give a ſulphureous quality to vitriolic acid, and are even capable of furniſhing ſulphur with that acid.

Although the experiments now mentioned were the only proofs of the exiſtence of an inflammable principle in metallic ſubſtances, theſe would be ſufficient to eſtabliſh it inconteſtibly. But we ſhall ſee, when we continue to examine the phenomena attending the decompoſition of metals, that thoſe are not the only proofs.

If the inflammable matter which ſhews itſelf ſo evidently in the burning of metals, is really one of their conſtituent parts, their eſſential properties muſt be altered in proportion to the quantity of it taken from them; and this evidently happens upon trial; for the reſiduum of metallic matters, after calcination, departs from the metallic character, and approaches to the nature of mere earth. The opacity, brilliancy, ductility, gravity, fuſibility, volatility, in a word, all the properties by which metallic ſubſtances differ from ſimple earths, diminiſh or entirely diſappear, by taking from them their inflammable principle; ſo that when their calcination has been carried as far as is poſſible, they reſemble mere earths, and have no longer any thing in common with metals. Theſe earths can no longer be combined with acids or with metals, but are capable of uniting with pure earths. They are then called *calxes* or *metallic earths*. *See* CALXES (METALLIC).

We muſt obſerve concerning the decompoſition of metals, 1. That when only a ſmall quantity of inflammable principle is taken from metals, a ſmall quantity only of calx is formed, and the remaining part continues in the metallic ſtate: hence, as the portion of calcined metal can no longer remain united with the undeſtroyed metal, it ſeparates in form of ſcales from the ſurface of the metal, when the calcination has been performed without fuſion, as generally happens to iron and to copper; or theſe ſcales float upon the ſurface of the melted metal when the calcination is performed during fuſion, becauſe the calx is ſpecifically lighter than the metal, as happens to the very fuſible metals, as tin, lead, and moſt of the ſemimetals.

2. The imperfect metals are not all equally eaſily and compleatly calcinable. In general, as much of their phlogiſton may be eaſily taken from them, as is ſufficient to deprive them of their metallic properties; but the remaining portion of their phlogiſton cannot ſo eaſily be driven from them. Some of them, as copper, reſiſt the firſt calcination more than the reſt; and others, as lead and biſmuth, may be very eaſily calcined, but only to a certain degree, and retain always obſtinately the laſt portions of their inflammable principle; laſtly, others, as tin and regulus of antimony, may not only be eaſily and quickly calcined, but alſo much more completely. All the other metals partake more or leſs of theſe properties relating to their calcination. In general, if we except the labors of alchemiſts, which are not much to be depended upon, we have not yet made all the proper efforts to arrive at a perfect calcination of the ſeveral metallic ſubſtances; which, however, is abſolutely neceſſary, before we can arrive at a complete knowledge of the nature of their earths, as we ſhall afterwards ſee.

When metallic earths have loſt but little of their phlogiſton, and are expoſed to ſtrong fire, they melt and are reduced to compact maſſes, ſtill heavy and opake, although much leſs ſo than the metals, and always brittle and abſolutely unmalleable. If the calcination has been more perfect, the metallic earths are ſtill fuſible by fire, but leſs eaſily, and convertible into brittle and tranſparent maſſes poſſeſſed of all the properties of glaſs, and are accordingly called *metallic glaſſes.* Theſe glaſſes do not poſſeſs any of the properties of their metals, excepting that they are ſpecifically heavier than other glaſſes, that they are capable of being attacked by acids, and that the glaſſes of the ſemimetals are ſomewhat leſs fixed than unmetallic glaſſes. Laſtly, when the calcination of metals has been carried to its greateſt height, their earths are abſolutely fixed, and unfuſible in the fire of our furnaces, and poſſeſs no longer the ſolubility in acids by which metals are characteriſed.

Theſe are the principal changes which metals ſuffer by loſing their phlogiſton. They are thus changed into ſubſtances which have no properties but thoſe of earth. This is a certain proof that the inflammable principle is one of their conſtituent parts. But we have alſo other proofs of this important truth. The reduction of metallic calxes into metal, by the addition of phlogiſton alone, completes the proof; and the whole forms one of the cleareſt and moſt ſatisfactory demonſtrations in all the ſciences. This reduction is effected in the following manner.

If the earth of a metal be mixed with any inflammable matter, which either is, or can be changed into the ſtate of coal, together with ſome ſalt capable of facilitating fuſion, but which, from its quantity or quality, is incapable of receiving the inflammable principle; and if the whole be put into a crucible, and the fuſion promoted by a fire gradually raiſed; then an efferveſcence will happen, accompanied with a hiſſing noiſe, which continues a certain time, during which the fire is not to be encreaſed; afterwards, when the whole has been well fuſed, and the crucible taken from the fire and cooled, we ſhall find at the bottom, upon breaking it, the metal, the earth of which was employed for the operation, poſſeſſed of all the properties which it had before calcination and reduction. *See* Reduction.

We cannot doubt that this wonderful transformation of an earthy ſubſtance into a metal is ſolely cauſed by the phlogiſton paſſing from the inflammable matter to the metallic earth; for, firſt, in whatever manner, and with whatever ſubſtance metallic earths be treated, they cannot be ever reduced into metals without a concurrence of ſome ſubſtance containing phlogiſton. 2dly, The nature of the ſubſtance which is to furniſh phlogiſton is quite indifferent, becauſe this principle is the ſame in all bodies containing it. 3. Laſtly, if after the operation the ſubſtance furniſhing the phlogiſton be examined, we ſhall find that it has loſt as much of that principle as the metallic earth has received

The facts related concerning the decompoſition and the recompoſition of metals prove inconteſtably, that they are all compoſed of earth and phlogiſton. But we do not yet certainly know whether theſe two be the only principles of metals. We might affirm this, if we could produce metals by combining phlogiſton with ſome matter which is certainly known to be ſimple earth. But this hitherto has not been accompliſhed; for if we try to treat any earth, which has never been metallic, with inflammable matters, we ſhall perceive that theſe ſimple earths are not combinable with phlogiſton, ſo as to form metals. We ſhall even perceive that the metallic earths reſiſt this combination, and are incapable of reduction into metal, when they have been ſo much calcined as very nearly to approximate the nature of ſimple earths.

Theſe conſiderations, added to this, that we cannot eaſily conceive how, from only two certain principles, ſo many very different compounds as the ſeveral metallic ſubſtances are, ſhould reſult, are capable of inducing a belief that ſome other principle is added to theſe two already mentioned in the compoſition of metals.

Many great chemiſts, and particularly Becker and Stahl, ſeem to be convinced of this opinion; and chiefly from the experiments concerning the mercurification of metals, they believe that this third principle exiſts copiouſly in mercury; that it is of a mercurial nature; that it alſo exiſts in marine acid, to which it gives its ſpecific character; that by extracting this mercurial principle from marine acid, or any other body containing it copiouſly, and by combining it with ſimple earths, theſe may acquire a metallic character, and be rendered capable of receiving phlogiſton, and of being completely metalliſed.

Theſe chemiſts admit alſo, and with probability, a different proportion of metallic principles in the ſeveral metals, and believe, that particularly the principle which they call *mercurial earth* exiſts more copiouſly and ſenſibly in certain metals than in others. The moſt mercurial metals, according to them, are mercury, ſilver, lead, and arſenic. Moſt chemiſts diſtinguiſh from the other metals, ſilver, mercury, and lead; which they call *white metals*, *lunar metals*, or *mercurial metals*.

All theſe conſiderations being united, and others too many to be mentioned, give ſome probability to the exiſtence of the mercurial principle in metals. We muſt however acknowledge, that the exiſtence of this principle is only merely probable, and, as Stahl obſerves, is not nearly ſo well demonſtrated as that of the inflammable principle: we may even add, that we have ſtrong motives to doubt of this exiſtence.

As marine acid, mercury, arſenic, and even the other ſubſtances in which the mercurial earth is ſuppoſed to abound, are very volatile, and that none of the properties attributed to it ſhew that it is fixed, it ſeems, if it does exiſt, to be neceſſarily volatile. The chemiſts who admit it, conſider it as volatile, ſince one of the methods beſt atteſted for the mercurification of metals is by ſubliming them through charcoal in Geber's manner, and ſince it is chiefly in the ſoot formed by the metals, that chemiſts look for their mercurial principle.

If then the mercurial earth be a volatile principle; when metals are decompoſed by combuſtion, or by detonation with nitre, a conſiderable part of this volatile mercurial principle muſt be diſſipated. Hence we ought not to be able to remetalliſe the calxes of metals, without recombining not only their loſt phlogiſton, but alſo their loſt mercurial earth. But from experience we know, that by addition of phlogiſton alone theſe calxes may be metalliſed, and that no mercurial principle is neceſſary. We cannot anſwer to this difficulty, that all ſubſtances containing phlogiſton contain alſo a ſufficient quantity of mercurial earth for the reduction of metallic calxes; for if that were true, we ſhould be able to produce metals by treating unmetallic earths with inflammable matters, ſince in ſuch a combination all the principles of metals would be preſent. But we have already obſerved, that this cannot be done.

When indeed metallic calxes are reduced, there is always ſome loſs of quantity, as the ſame weight of metal is never procured which exiſted previouſly to the calcination; and alſo the more complete the calcination has been, this loſs of weight will be ſo much the more conſiderable. We may conſequently attribute this loſs to that of the mercurial principle, during the decompoſition of the metal, and which is not reſtored to it by reduction with phlogiſton alone.

But may we not as reaſonably believe, that if ordinary earths, or even metallic earths perfectly calcined, cannot be metalliſed, this proceeds only from the difficulty of commencing an union with ſubſtances ſo different as earth and phlogiſton? but when this union is once begun by nature, the earth is then much more diſpoſed to combine intimately with a ſufficient quantity of phlogiſton to conſtitute it a metal; that thus any earth, entirely free from phlogiſton intimately combined, is, relatively to us, an unmetallic earth, whether it be naturally found in that ſtate, as almoſt all ſubſtances are, which we call ſimply *earths*, or whether it be a metallic ſubſtance perfectly calcined. Hence the mercurial earth would be nothing elſe than phlogiſton, or rather is not a diſtinct ſubſtance, ſince it conſiſts only in a beginning of union of phlogiſton with earth, or in a diſpoſition which an earth has of uniting intimately with the inflammable principle. This is an idea of the celebrated Henkel, whom we certainly cannot ſuſpect of indifference or incredulity concerning the poſſibility of the artificial production of metals.

If this opinion were well grounded and proved, the artificial production of metals would be, in fact, not only poſſible, but much leſs difficult than has hitherto been believed; for only two principles are, in this caſe, neceſſary to be combined to form a metal. We ſhould then have nothing to do with the mercurial principle, the moſt troubleſome of all, the moſt untractable, the leaſt diſtinctly known, and the exiſtence of which is not even aſcertained.

But notwithſtanding theſe conſiderations, we muſt not believe that the production of metals is not one of the moſt difficult problems in chemiſtry. The reflexions we ſhall add upon this ſubject will be ſufficient demonſtration to every ſenſible perſon, that great knowledge is requiſite in that ſcience, to attempt with any hopes of ſucceſs, the production even of the moſt imperfect ſemimetal; they will ſhew the folly of thoſe who attempt to make gold and ſilver, without being poſſeſſed of any knowledge even of elementary chemiſtry, which they deſpiſe and call *vulgar chemiſtry*, of which they diſdain to inform themſelves, although elementary knowledge be in chemiſtry, as in every other ſcience, the moſt eſſential, fundamental, and neceſſary for further attainments. By a ſingular fatality, the moſt ignorant perſons are the moſt preſuming. They who ſee what paſſes in the particular aſſemblies of the Academy of Sciences, know that this illuſtrious ſociety is always beſet with pretenders to geometry, who really believe they have diſcovered the quadrature of a circle, the perpetual motion, &c. and who at the ſame time are ſo ignorant of the firſt elements of algebra and geometry, that they are incapable of perceiving the demonſtrations of their errors. Happily the perſons who imagine that they have diſcovered the means of making gold, are not ſo communicative, and keep their ſecrets in hopes of enriching themſelves, otherwiſe the Academy would be as much importuned by the adepts of the philoſophers ſtone, as it is now by the ſquarers of a circle.

To return to the artificial production of metals, we muſt obſerve, that even if we were certain, that it depends only on the intimate combination of the inflammable principle with a matter ſimply earthy, we ſhould labor by chance, and without any reaſonable expectation of ſucceſs, if we were to attempt that combination, without having more knowledge than we now poſſeſs, concerning the true nature of the earthy principle which enters into the compoſition of metals; for we muſt acknowledge that chemiſtry has made but little progreſs in this matter.

Metallic ſubſtances, although they reſemble each other by the general properties mentioned in the beginning of this article, differ nevertheleſs from each other very evidently by the properties peculiar to each. Do theſe differences proceed from the different proportion, and from the more or leſs intimate connexion of the inflammable principle with the earthy principle, ſuppoſing that this latter ſhould be eſſentially the ſame in all metals? or ought they to be attributed to the difference of earths, which, in that caſe, would be diſtinct and peculiar to each metal? or, laſtly, do metals differ from each other, both by the nature of their earths, and by the proportion and intimacy of connexion of their principles? All theſe things are entirely unknown, and we may eaſily perceive, that till they are known, we cannot diſcover what method to purſue in our attempts to accompliſh the combinations we are now treating of.

The moſt eſſential point then is to arrive at a knowledge of the true nature of the earths which are in metals; and the only method of arriving at this knowledge is, to reduce them to their greateſt ſimplicity by a perfect calcination. But this cannot be accompliſhed but by long and difficult operations. We have ſeen above, that all metals are not calcinable with equal eaſe; that the perfect metals have not been hitherto calcined truly, by any proceſs; and that in general the laſt portions of phlogiſton adhere very ſtrongly to calcinable metals.

Some metals, however, as tin and regulus of antimony, may be eaſily calcined ſo as to be rendered irreducible. By carrying the calcination ſtill further, by the methods known in chemiſtry, we might obtain their earths ſo pure, that all their eſſential properties may be diſcovered, by which they might eaſily be compared together. This compariſon would decide whether their nature be eſſentially different, or not.

If they were found to be compoſed of earths eſſentially the ſame, we might next proceed to compare metallic with unmetallic earths. If the former were found ſimilar to ſome of the latter kind, we ſhould be then aſſured that the earth of metals is not peculiar to them, and that ordinary unmetallic earths are ſuſceptible of metalliſation.

The greater the number of metals operated upon, the more general and certain the conſequences reſulting from theſe would be; ſo that, for inſtance, if the operation were extended to all calcinable metals, and if the reſult of each of theſe operations were, that the calxes, when perfectly dephlogiſticated, do not differ from each other, and are ſimilar to earths already known, we might conclude from analogy, and we ſhould be almoſt certain, that the earths of the perfect metals are alſo of the ſame nature.

They who know the extent and difficulties of chemical operations, will eaſily perceive that this would be one of the moſt conſiderable. Nevertheleſs, after having determined this eſſential point, we ſhould only have done half our work. For a knowledge of the nature of the earth of metals, and where it is to be found, would not be ſufficient; we muſt further endeavor to find a method of combining with this earth a ſufficient quantity of phlogiſton, and in a manner ſufficiently intimate, that a metal might be formed by ſuch a combination. We here always ſuppoſe, that earth and phlogiſton are the two only principles of metals. I ſay, then, that the method of combining theſe two principles muſt be diſcovered; for we know that the ordinary proceſſes, thoſe, for example, which are employed for the reduction of metals, are inſufficient in this caſe. But this ſecond difficulty is perhaps greater than the former.

When we reflect on the fundamental rules of the union of bodies, we ſhall diſcover a road which may lead to this combination. In fact, if it be true, as every thing ſeems to demonſtrate, that all natural ſubſtances may be united together, and that the reſiſtance made by ſome to this union proceeds from the too ſtrong union of their integrant parts, then the difficulties which occur in attempting to combine intimately phlogiſton with earth, which of all known ſubſtances has the ſtrongeſt aggregation, can only proceed from the too great adheſion of the integrant parts of earth to each other. Hence the only method of diſpoſing to this union, is to ſeparate and inſulate the primary integrant parts ſufficiently, and to break the aggregation as much as is poſſible.

The integrant parts of earth may indeed be well diſjoined, when fuſed by a ſtrong heat: therefore, if it were poſſible to fuſe perfectly a ſimple earth, previouſly mixed with ſome inflammable matter, and put into a veſſel accurately cloſed (which circumſtance is abſolutely neceſſary to prevent the combuſtion of the inflammable principle) the phlogiſton would probably unite intimately with this earth, and a metallic matter would reſult from it. But this method ſeems to be impracticable, becauſe ſimple earths are too refractory to be fuſed without addition, by the ſtrongeſt fire which can be made in furnaces.

We may indeed facilitate, as much as we pleaſe, the fuſion of earths, by the addition of ſaline fluxes; but this method, which ſucceeds very well for the reduction of metallic earths, when they have not been too much dephlogiſticated, and when therefore they preſerve a diſpoſition to be metallized, becomes inſufficient to reduce theſe earths, when they have been too much calcined; and it muſt be much more inſufficient with regard to ſimple earths, which have never been in a metallic ſtate.

The reaſon of this is, that to procure the union of one body with another, not only the aggregation of that body muſt be broken, but alſo when this disjunction of aggregation is occaſioned or facilitated, as in the preſent caſe, by the interpoſition of the parts of ſome ſubſtance, this ſubſtance muſt not have a too great affinity with the body to be united to that whoſe aggregation is broken, as may eaſily be underſtood.

But we are certain that all the ſaline matters, which may be employed to facilitate the fuſion of earths, have themſelves a very great affinity with the inflammable principle; and the greater this affinity is, the more it ought to weaken the tendency which the inflammable principle has to be combined with the parts of earth.

Here then is a compenſation. For if, on one ſide, the ſalts, while they facilitate the fuſion of the earth, place it in a more favorable ſtate for combination with phlogiſton; on the other ſide, the affinity of theſe ſalts with phlogiſton diminiſhes in the ſame proportion the diſpoſition which the phlogiſton has of combining with the earth; and therefore we need not wonder that this combination ſhould not take place.

But the caſe is different, when the earth intended to be metalliſed by the addition of phlogiſton, is previouſly united intimately with a certain quantity of that principle, as happens in metallic calxes not perfectly dephlogiſticated. For this phlogiſton, ſtrictly united with the earth, not only much diminiſhes the force of its aggregation, but it muſt alſo neceſſarily facilitate very greatly the accretion of a new quantity of phlogiſton, from the ſtrong diſpoſition of bodies to unite with others of the ſame nature.

Hence we cannot hope to ſucceed in trials of this kind by fuſion with an intenſe fire: but theſe are not the only reſources which chemiſtry offers to us. We are very certain, that the metallic combinations formed daily by nature, are not effected by violent fuſions. Water kept in a fluid ſtate by the little heat neceſſary for that purpoſe, is itſelf capable of keeping the integrant parts of bodies whoſe aggregation is broken, ſuſpended and inſulated from each other, and thoſe of earth, as well as of other ſubſtances, as is evidently demonſtrated by ſediments, ſtalactites, cryſtallizations, ſtones of all ſorts, which are formed every where by water. Water alſo of all ſubſtances has the leaſt affinity with phlogiſton, and conſequently has all the requiſite conditions as a vehicle, to aſſiſt the combination of earth with phlogiſton: Laſtly, we know from experience that metals may be decompoſed, and that their calxes may be metalliſed as well by the humid as by the dry way. *See* REDUCTION.

Water, then, ſeems to be a very proper intermediate ſubſtance to form the firſt rudiments of metalliſation, and is employed by nature for the production of metals, minerals, and of all the compound bodies that we ſee. According to the opinion of one of our greateſt naturaliſts and philoſophers, nature makes with water all that we make in our laboratories with fire, and many others which we cannot accompliſh. Water is her principal and almoſt only inſtrument. By water, therefore, that is, by the humid way, the combinations now in queſtion ought to be attempted.

But, it may be ſaid, nature employs an almoſt infinitely long time for moſt of her productions, and particularly for metallic combinations. Can this time be ſhortened by chemical means? Does chemiſtry furniſh a method of impregnating water with the primitive integrant molecules of earth, and with a ſufficient quantity of inflammable principle? We have reaſon to preſume it. Nevertheleſs, to be able to affirm any thing upon this ſubject, a perſon ought to have made experiments with theſe views; which, I confeſs, I never have done.

We ſhall not enter into a further detail upon this matter, that we may not prolong this diſcuſſion, perhaps too long already, and too conjectural for a work of this nature. We thought ſome extent ought to be given to it, not only becauſe the ſubject is itſelf intereſting, but alſo becauſe many perſons, particularly thoſe who are ignorant of the whole extent of chemiſtry, conſider metalliſation as the ſole object of that ſcience. It has been almoſt the ſole end of chemiſts, from time immemorial to the renovation of the ſciences, that is, to late times.

All the ancient chemiſts were ſolely engaged about metals. Their views and inquiries were ſo directed to that point, that they entirely neglected whatever was not connected with it; ſo that the name of chemiſt gave the idea of a man who endeavored to make metals. The inſuperable obſtacles they have met, have obliged them to multiply their experiments, and to work upon many bodies beſides metals. The properties of many ſubſtances have been thus diſcovered ſucceſſively; and theſe multiplied diſcoveries, having been afterwards generaliſed, and arranged, have given birth to the philoſophical chemiſtry now cultivated; to that chemiſtry which explains clearly, which proceeds with order and method, and which in this reſpect differs greatly from the ancient reſearches concerning the philoſopher's ſtone.

We do not now undertake with the ſame confidence and ardor as heretofore the ſolution of the moſt difficult problems. The ſlow and circumſpect progreſs of chemiſtry appears humble and timid, in compariſon of the bold and rapid courſe of ancient alchemy: but ſuch is the conſequence of experience and reflection.

When men have long wandered at random; when, after they have fatigued themſelves with every trial that occurred, without rule or meaſure, they have failed in their attempts; their moſt reaſonable conduct is to return as they came, to begin afreſh, and not to engage in the purſuit till the proper road be well aſcertained.

We do not conſider as certain guides the ideas which the nature of the ſubject, and the deſire of contributing to the advancement of the art, and of inſpiring a true taſte for it, have induced us to ſuggeſt on metalliſation in this article. If, in purſuing theſe ideas, we ſhould be able to produce the rudeſt beginning of a metal or ſemimetal, true chemiſts would certainly find much cauſe of aſtoniſhment and admiration. Much farther are we from preſuming that by this method the perfect metals, as gold and ſilver, can be produced. We do not intend to excite too flattering hopes, but only to preſent a rational plan of ſuch labors, and to ſhew the difficulties to thoſe who chuſe to undertake them.

We ought to advertiſe here, that ſome famous chemical proceſſes have been conſidered by many as metalliſations, but which are really not ſo. Such is Beccher's famous experiment of the *Minera arenaria perpetua*, by which that chemiſt propoſed to the States General to extract gold from any kind of ſand. Such alſo is the proceſs of Beccher and of Geoffroy, to obtain iron from all clays by treating them with linſeed oil in cloſe veſſels. In theſe, and many other ſuch proceſſes, we do only obtain metal that was already formed. Every earth and ſand, as the intelligent and judicious Cramer obſerves, contain ſome particles of gold. Clays do not commonly contain iron ready formed, but all of them contain a ferruginous earth, naturally diſpoſed to metalliſation. *See* CLAY. Accordingly we muſt conclude, that, by Mr. Geoffroy's experiment, iron is only reduced or revived, but is not produced.

The great difficulties which occur in attempting to give a metallic quality to ſimple earths have induced a belief, that the nature of metals ready formed might be more eaſily changed, and the leſs perfect brought to a more perfect ſtate. To effect this, which is one of the principal objects of alchemy, and is called tranſmutation, numberleſs trials have been made. As we have not any certain knowledge of what occaſions the ſpecific differences of metallic ſubſtances, we cannot decide whether tranſmutation be poſſible or not. In fact, if each metallic ſubſtance have its peculiar earth, eſſentially different from the earths of the others, and conſequently if the differences of metals proceed from the differences of their earths; then, as we cannot change the eſſential properties of any ſimple ſubſtance, tranſmutation of metals muſt be impoſſible. But if the earths and other principles of metals be eſſentially the ſame, if they be combined in different proportions only, and more or leſs ſtrictly united, and if this be the only cauſe of the ſpecific difference of metals, we then ſee no impoſſibility in their tranſmutation.

Whatever be the cauſe of the differences of metals, their tranſmutation ſeems to be no leſs difficult than the production of a new metallic ſubſtance; and perhaps it is even more difficult. Alchemiſts, whom nothing aſtoniſhes or embarraſſes, believe that tranſmutation is poſſible, and they even affirm that they have effected it. They begin by ſuppoſing that all metals are compoſed of the ſame principles, and that the imperfect metals do not differ from gold and ſilver, but becauſe their principles are not ſo well combined, or becauſe they contain heterogeneous matters. We have then only theſe two faults to remedy, which, as they ſay, may be done by a proper coction, and by ſeparating the pure from the impure. As we have but very vague and ſuperficial notions concerning the cauſes of the differences of metals, we confeſs that we cannot make any reaſonable conjecture upon this matter; and we ſhall only adviſe thoſe who would proceed upon good principles, to determine previouſly, if metals have each a peculiar earth, or only one common to them all. In the ſecond place, if it ſhould be demonſtrated that the earthy principle is the ſame in all metals, and if that be demonſtrated as clearly as the identity of the inflammable principle in metals is proved; they muſt then determine whether theſe two be the only principles in metals, whether the mercurial principle exiſts, and whether it be eſſential to all metals, or to ſome only, and what is the proportion of theſe two or three principles in the ſeveral metallic ſubſtances. When we ſhall clearly underſtand theſe principal objects, we may then be able to determine concerning the poſſibility of tranſmutation; and if the poſſibility ſhould be affirmed, we ſhall then begin to diſcover the road which we ought to purſue.

We have no reaſon to believe that any other principle enters into the compoſition of metals than thoſe above-mentioned; no veſtige is perceptible of either air or water. Some chemiſts have nevertheleſs advanced that they contain a ſaline principle. If that were true, they would alſo contain a watery principle. But all the experiments adduced to prove this opinion are either falſe, or only ſhew the preſence of ſome ſaline particles extraneous to the metals, or contained unknown to the chemiſts in the ſubſtances employed in the experiments. For metals perfectly pure, ſubjected to all trials with ſubſtances which do not contain, and which cannot produce any thing ſaline, do not diſcover any ſaline property. We muſt however except arſenic, and even its regulus, theſe being ſingular ſubſtances, in which the ſaline are as ſenſible as the metallic properties.

Arſenic ſeems to be one of thoſe intermediate ſubſtances which nature has placed in almoſt all its productions betwixt two different kinds, and which partake of the properties of each kind. Arſenic thus placed betwixt metallic and ſaline ſubſtances has properties common to both theſe kinds of ſubſtances, without being either entirely a metal or a ſalt. *See* ARSENIC.

As water ſeems to act to a certain degree upon iron, even without the concurrence of air, as the operation of martial ethiops ſhews, we might thence ſuſpect ſomething ſaline in that metal. Nevertheleſs, I do not believe that what happens in that operation has been ſo well explained, that any certain conſequences can be deduced. 1. The water employed ought to be perfectly pure, that is, diſtilled rain water. 2. The iron employed ought alſo to be perfectly pure, and ſuch is very difficultly to be procured. 3. The operation ought to be performed in a bottle accurately cloſed, that we may be aſſured that the air contributes nothing to the action upon the iron. 4. After the water has remained a long time, ſuppoſe a year, upon the iron, the water ought to be carefully filtrated and examined, to aſcertain whether it really has diſſolved any part of the metal.

In the mean time, we may conclude that metals do not ſeem to contain any ſaline principle. And when we conſider well their general properties, they ſeem to be nothing elſe than earths combined more or leſs intimately with a large quantity of phlogiſton. Although we can demonſtrate that their inflammable principle is not in an oily ſtate; and that it is pure phlogiſton, they have nevertheleſs an oily appearance, in this circumſtance, that they adhere no more than oils to earthy and aqueous ſubſtances, and that they always aſſume a globular figure when ſupported by theſe ſubſtances entirely free from phlogiſton.

This reſemblance is ſo ſenſible, that chemiſts, before they knew the nature of phlogiſton, believed that metals contained an oily and fat matter; and even now many perſons, who talk of chemiſtry without underſtanding it, ſpeak of the *oil, or fat of metals*; expreſſions, which do not ſound well to genuine chemiſts. The cauſe of this quality of metals is the quantity of phlogiſton which they contain. Sulphur, phoſphorus, oils, and even fats, have this appearance merely from the inflammable principle which enters into their compoſition: for this property is communicated by that principle to every compound which contains a certain quantity of it. *See* PHLOGISTON.

When the phlogiſton combines copiouſly and intimately with earthy matters ſo as to form metals, it probably ſo diſpoſes them that the primitive integrant parts of the new compound, that is, of the metal, approximate and touch each other much more than the integrant parts of ſimple earths can. This is proved by the great denſity or ſpecific gravity, and other general properties, of metals.

In fact, as we cannot conceive that a body ſhould be tranſparent, unleſs it have pores and interſtices through which rays of light can paſs, therefore the more denſe a body is, that is, the fewer ſuch interſtices it has, the leſs tranſparent it will be; ſo that the denſeſt bodies ought to be the moſt opake; as in metals. The diſpoſition of the pores of bodies contributes alſo much to their greater or leſs tranſparency; and bodies, the pores of which are continued and ſtreight, are more tranſparent than thoſe whoſe pores are interrupted, tranſverſe, or oblique; ſo that a body may be much more tranſparent than another which is leſs denſe; as we ſee that glaſs is more tranſparent than charcoal. But when other circumſtances are equal, the denſeſt bodies are the moſt opake. Therefore the opacity of bodies is proportionable to their denſity, and to the deviation of their pores from right and parallel lines.

From the great opacity of metals, they probably poſſeſs both theſe qualities in an eminent degree. We have ſeen, at the beginning of this article, that the luſtre of metals and their property of reflecting light much better than any other ſubſtance, are neceſſary conſequences of their opacity. This is alſo ſelf-evident, becauſe the fewer rays any bodies can tranſmit, the more it muſt reflect.

Laſtly, the ductility of metals proceeds alſo from their denſity, and from the diſpoſition of their pores, as we have explained under the word DUCTILITY. Phlogiſton alſo appears to communicate ductility to moſt of the bodies containing it, as we ſee in ſulphur, and unctuous bodies, as reſins, wax, &c. all which are more or leſs ductile, at leaſt when heated to a certain degree. Laſtly, the ſoftneſs, fuſibility, and volatility of which all metals partake more or leſs, and which many of them poſſeſs in a ſuperior degree, being properties entirely contrary to thoſe of the earthy principle, probably proceed from the inflammable principle. In general, if we reflect on the eſſential properties of the earthy and inflamrable principles, we ſhall eaſily perceive that theſe properties, being combined and odified by each other, ought to produce the properties of metals. In order erefore to underſtand all this article, the words EARTH and PHLOGISTON ught to be conſulted.

The order in which metals compared with each other poſſeſs moſt eminently eir principal properties, is the ſame as that in which they are here enumerated, eginning always with that metal in which the property is moſt conſiderable.

1. *Specific gravity* or *denſity.* Gold, platina, mercury, lead, ſilver, copper, ron, and tin.

2. *Opacity.* We cannot well compare metals with each other in this reſpect, ecauſe it is ſo conſiderable in all that it ſeems complete. If, however, they differ n this reſpect, the ſame order will ſerve for opacity as for denſity.

3. *Metallic luſtre* or *brilliancy.* The ſame obſervation which was made conerning the laſt-mentioned property is applicable to this alſo. We muſt however obſerve, that as, by poliſh, bodies are rendered brighter, and that as whiteneſs ontributes much to the reflexion of light, the whiteſt and hardeſt metals thereore reflect beſt. Hence platina ought to be placed firſt, and then iron or ather ſteel, ſilver, gold, copper, tin, lead. (z)

4. *Ductility.* Gold, ſilver, copper, iron, tin, lead. The ductility of mercury nd of platina are not yet determined.

5. *Hardneſs.* Iron, platina, copper, ſilver, gold, tin and lead.

6. *Tenacity.* By tenacity we underſtand the force with which the integrant parts f metals reſiſt their ſeparation. This force appears to be in a compound ratio f their ductility and hardneſs. The comparative tenacity of metals is meaſured y the weight which wires of the ſame diameter, made of the ſeveral metals, can ſuſtain without breaking. Gold is the moſt tenacious, then iron, copper, ſilver, tin, lead. The tenacity of mercury is unknown: That of platina is not yet determined, but is probably conſiderable.

7. *Fuſibility.* Mercury, tin, lead, ſilver, gold, copper, iron, and laſtly platina, which cannot be fuſed by the greateſt fire of our furnaces, but only by the ſolar focus, as Meſſrs. Macquer and Beaumé have determined.

(z) Hardneſs of metals may contribute much to the duration of their poliſh; but certainly ſoft metals, if their texture be equally compact, are no leſs capable of receiving a poliſh than hard metals. Some hard metallic allays have been found to be leſs liable to tarniſh than ſofter compounds, and have for this reaſon alſo been chiefly uſed for ſpeculums. The property of reflecting light ſeems chiefly to depend on the cloſeneſs of the particles, or on the denſity, on the ſmoothneſs of the ſurface, and on the color being moſt ſimilar to the color of the light to be reflected. The white metals, ſilver, mercury, tin, reflect light more abundantly than others. Gold being the denſeſt metal, and perhaps becauſe the color of ſolar light has a ſlightly-yellowiſh tinge, does alſo reflect light very copiouſly. Hence ſpeculums made of leaf-gold have been found to be very effectual. Iron or ſteel reflects much leſs light than any of the above-mentioned metals, although the author has conſidered it as capable of a greater reflective power. Platina is generally in ſo ſmall grains, that its reflective power cannot eaſily be determined. The preciſe degrees of that power which ought to be aſſigned to each of the above-mentioned metals, cannot without accurate experiments be aſcertained. However, I think, their reflective powers will be found to be more nearly in the following order, than in that mentioned in the text. Silver, quickſilver, tin, gold, copper, iron, lead.

The table of affinities of Mr. Geoffroy gives for metallic ſubſtances in general, marine acid, vitriolic acid, nitrous acid, vegetable acid. Mr. Gellert's table contains no column for metallic ſubſtances in general.

The uſes of metals are numberleſs and great. Their particular uſes ſhall be mentioned under the articles of the ſeveral metallic ſubſtances.

CCCCL. MICA. (*a*)

CCCCLI. MILFOIL. (*b*)

CCCCLII. MILK, *and* WHEY. The milk of animals is a white liquor compoſed of three very different ſubſtances, namely, butter, cheeſe, and whey. Theſe three matters are intimately mixed with each other in freſh milk. Whey is the only fluid part of milk. Butter and cheeſe, which are mixed with it, have each of them a certain ſolidity, and are not ſoluble by whey. Theſe two matters, the former of which is entirely of an oily nature, and the ſecond is gelatinous or mucilaginous, are only interpoſed and ſuſpended in the ſerous part by being very much divided.

Hence we ſee that milk is a true emulſion. Butter compoſes its oily part, which by the interpoſition of its particles gives an opake white color; the cheeſe ſerves as a mucilage to keep the oily part ſuſpended; and, laſtly, whey, which is naturally tranſparent, is the aqueous ſubſtance, which is a vehicle for the other two. Milk may then be juſtly called an animal emulſion. From its properties we ſhall ſee that this name ſuits it in every reſpect.

Milk, recently taken from a frugivorous animal in good health, and fed with proper aliments, gives not by chemical trials any marks of an acid or alkaline quality. It has a ſweet, agreeable, and ſomewhat ſaccharine taſte; it contains no parts that are volatile with the heat of boiling water, at leaſt in any ſenſible quantity, ſo as to be collected. Its ſmell, which is peculiar to it, is very weak.

This liquor is very ſuſceptible of alteration; the ſmalleſt quantity of acid is capable of coagulating it. When an alkali is mixed with it, a kind of coagulation happens, which is very different from that which is occaſioned by an acid.

(*a*) MICA, or *Talk*, is an earthy or ſtony ſubſtance conſiſting of thin, flexible, ſhining plates. Theſe plates by expoſure to fire become brittle, crumple, and by violent heat are vitreſcible. *See* Mr. D'Arcet's Memoir on the effects of a long and violent fire. Mica is either colorleſs and tranſparent; or it is colored, red, brown, green, or black, and ſemi-tranſparent. The colored micas generally contain ſome metallic matters, chiefly iron, and as Mr. Juſti ſays, a new metallic ſubſtance [*ſee the laſt note* (*y*)], and are much more fuſible than thoſe which are pure and colorleſs. Micas have a ſoft touch reſembling that of unctuous ſubſtances. They are not ſoluble by acids, they are incapable of eliciting ſparks when ſtruck by ſteel, as flints do, or of forming a tenacious paſte with water, as clay does; or of hardening, when mixed with water, as gypſum does. Mica is therefore neither a calcareous, ſiliceous, argillaceous, nor gypſeous earth. The colorleſs tranſparent mica, called *Muſcovite-glaſs*, is uſed as panes for windows. In Jemptland, a crumpled kind of mica is manufactured into kettles and other veſſels, and alſo for hearths.* The powder of this ſtone is mixed with ſea-ſalt, and from the mixture marine acid is obtained by diſtillation.

(*b*) MILFOIL or YARROW. The flowers and tops of the common purpliſh-flowered milfoil afford a blue oil ſimilar to that of camomile. Theſe flowers have an aromatic and not diſagreeable ſmell, and ſomewhat of a rough, bitter and pungent taſte. The bitterneſs and aſtringency remain in the extracts made by water or by ſpirit. From an ounce of milfoil-tops, water extracted three drams and a ſcruple, and ſpirit extracted from the ſame quantity two drams and a half.* *Neuman.*

This difference proceeds from the action of the alkali upon all the parts of the milk, and eſpecially upon the butyraceous part, to which it gives a ſaponaceous quality.

Milk alſo very readily ſuffers ſeveral remarkable changes, without addition of other ſubſtance. The oily or butyraceous parts of the milk, being ſpecifically lighter than the reſt, and adhering but weakly, ſeparate in great quantity by reſt alone, and are collected on the ſurface, preciſely as the oily parts ſeparate from emulſions. They there form what is called *cream*, from which, when collected, butter is made. Milk is alſo ſuſceptible of a ſpontaneous fermentation, by which it becomes acid, and is coagulated.

The coagulation of milk occaſions a diſtinct ſeparation of the caſeous part from the ſerous; and as this latter continues to ſeparate, the former acquires a greater ſolidity. By coagulation then, theſe two parts of milk are obtained ſeparately from each other. But the manner, in which this coagulation is made, produces conſiderable differences in the qualities of both. Wherefore milk is coagulated by different methods, according to the purpoſes for which the cheeſe and the whey are intended.

As the acid, which diſcovers itſelf in the milk when it curdles ſpontaneouſly, is more than is ſufficient for its coagulation, and as it communicates its taſte both to the cheeſe and to the whey, milk is not generally left to curdle ſpontaneouſly, either for the making of cheeſe for aliment, or of whey for medicine. This ſenſible acidity is avoided, by mixing with the milk, before it has become too old, the ſmalleſt quantity of acid neceſſary for coagulation, and by accelerating this coagulation by a convenient heat.

The common and alſo the beſt method is to dilute, in three or four ſpoonfuls of water, about 18 grains of runnet for every two pounds of milk, and to mix it with the milk, which is then to be placed upon hot embers. The milk, by means of this runnet, curdles more or leſs quickly according to the degree of heat given to it. When the curd is intended to be eaten before the whey is ſeparated, the heat ought to be very gentle, and the coagulation ſlow. If cheeſe be intended to be made of it, more expedition may be uſed; and as ſoon as the milk is curdled, it is to be cut, to allow the whey to ſeparate from it by draining. If this be done for the ſake of the whey, more heat may be given, and the ſeparation may be more expeditious. It is then to be paſſed through a ſtrainer.

The butyraceous, caſeous, and ſerous parts are ſeparated by theſe operations only imperfectly. Each of theſe three matters partakes of the other two. The butter and the cheeſe are purified in the manners mentioned under their particular articles. The whey muſt be cleared from the caſeous particles it contains, and which had not been curdled ſufficiently, by throwing in and mixing well with it a liquor made by boiling about 15 grains of cream of tartar in water, and alſo the white of an egg; after which the whey is to be filtered through brown paper.

The runnet employed to curdle milk is nothing elſe than a milky matter found in the ſtomachs of calves. This matter is uſually ſalted that it may be kept. It ſmells of old cheeſe, and coagulates milk, becauſe it contains a ſufficient but not ſenſible quantity of acid. It is a kind of leaven capable of producing the acid fermentation of milk. The ſame may be ſaid of ſeveral other ſubſtances, ſuch as the flowers of almoſt all thiſtles, of wall-flower, hence called curdle-milk, &c. All theſe matters which do not ſeem acid, and which do not communicate any ſenſible acidity to milk, curdle it very well, undoubtedly from the latent acid which they contain. The operation for clarifying whey is neceſſary, becauſe it could not otherwiſe be filtered from the caſeous particles adhering to it, which muſt be curdled again, or more ſtrongly by boiling with the cream of tartar and white of an egg. *See* Filtration.

Well clarified whey is very far from being a pure phlegm. It is indeed the moſt watery part of the milk, but it is alſo impregnated with all the parts of the milk which are ſoluble in water. It has accordingly a ſenſible taſte, which becomes very evident, when the whey is evaporated to nearly one half of its quantity. It is ſaccharine and ſomewhat ſaltiſh. In whey is contained diſſolved a conſiderable quantity of extractive ſubſtance of the nature of ſaccharine juices, and it is accordingly ſuſceptible of the ſpirituous fermentation. The Tartars certainly make from it a ſpirituous drink, or kind of wine.

Whey contains, beſides this ſaccharine fermentable ſubſtance, ſeveral kinds of ſalts which may be obtained by cryſtallization. If three fourths of clarified whey be evaporated, and if the remainder be then ſet in a cool place, a certain quantity of reddiſh cryſtals will be formed. This is the eſſential ſalt of milk. It is called the *ſugar of milk*, from its taſte, which is manifeſtly ſaccharine. But this color and taſte are extraneous to the ſalt, and proceed from the extractive matter of the liquor in which the ſalt was cryſtallized. Accordingly, if the cryſtals are well drained, diſſolved in pure water, and cryſtallized, they will be much whiter and leſs ſaccharine. By repeating the operation a third or a fourth time, the cryſtals may be rendered perfectly white and almoſt taſteleſs.

This ſalt is of a ſingular nature, but is little known, becauſe it has not been well examined. We know only that it is not deliqueſcent, and requires much water to diſſolve it: Mr. Beaumé has promiſed in his Pharmacy, that he will publiſh ſome particulars relative to this ſubject, which cannot fail of being intereſting.

The liquor which furniſhed theſe firſt cryſtals contains alſo ſome more, which may be obtained by continuing the evaporation and cryſtallization. If the evaporation be ſtill continued after the formation of the ſecond cryſtals, ſome common ſalt will be formed; and laſtly the mother-water contains, as Mr. Beaumé affirms in his Pharmacy, ſome fixed alkali, which conſequently is obtained without burning. As this alkali is not ſenſible either in milk or in whey before the above-mentioned operations, it probably exiſts in the milk, combined with ſome matter with which it is ſaturated, and which is ſeparated from it by theſe operations. All this requires a further and more particular inquiry.

Milk, and conſequently whey, contains no principle more volatile than water, and therefore none of its other principles are loſt by expoſure to the heat of boiling water. But if we diſtill in a naked fire the reſiduum of whey, evaporated in a ſand-bath to dryneſs, as Mr. Geoffroy has done, phlegm will be at firſt obtained, then a citron-colored acid ſpirit, and afterwards a thickiſh oil: laſtly, a reſiduous coal will remain in the retort, which will become moiſt by expoſure to air, from the ſaline ſubſtances with which it is mixed.

What we have ſaid concerning whey, together with the explanations we have given under the articles, Butter *of* Milk, and Cheese, are ſufficient to give juſt notions concerning the nature of milk. The reſult is, that milk is a mixture, firſt, of butter, which is an uncombined oleaginous matter, of the nature of fat, and not volatile, ſweet oils (*ſee* Oil); ſecondly, of cheeſe, which is a more earthy matter, containing oil combined nearly in a mucilaginous ſtate; and, thirdly, of whey, which is a watery liquor containing ſeveral ſalts, together with a ſaponaceous ſubſtance, or oil combined in the ſame manner as the oils of ſaccharine juices.

Milk is much employed in aliments and in medicine. It is ſoftening, incraſſating, cooling, reſtorative, and healing. It is proper againſt a ſharpneſs of humors, as tetters, eryſipelas, or gout, when theſe diſeaſes are not accompanied with fever; and againſt internal ſuppurations, phthiſis, maraſmus, and ſlow fevers. Sick perſons are frequently dieted with milk alone, and generally with good effect. But we muſt obſerve, that although milk be a food already prepared by nature, and as it were half-digeſted, it does not agree with all conſtitutions. It is apt to occaſion one of two very oppoſite diſorders, fluxes and coſtiveneſs. This is remedied by diluting it with water, or by proper correctives, or by chuſing that kind of milk which ſuits beſt with the conſtitution, and the diſeaſe to be treated. The milk of goats, for inſtance, has been obſerved to ſuit better than cows milk, with thoſe perſons whoſe conſtitution diſpoſes them to diarrheas.

Whey is not uſed as an aliment, becauſe being deprived of the butyraceous and caſeous parts of the milk which are alimentary, it is much leſs nouriſhing than milk. It affords, nevertheleſs, a little nouriſhment by means of the ſaccharine matter which it contains. Like milk, it is ſoftening and cooling, and may be employed as ſuch in the ſame diſeaſes, but it is much more diluting, aperitive and laxative. It is frequently uſed as a vehicle for other remedies.

We are far from having concerning milk all the knowledge which is to be wiſhed. Many inquiries remain yet to be made on this ſubject. For beſides the ſalt of milk, which is almoſt only known by name, nobody has hitherto undertaken a chemical examination, and a compariſon of the ſeveral kinds of milk drawn from different animals, which milks do nevertheleſs differ conſiderably from each other, as has been obſerved in the Elements of Practical Chemiſtry. Conſiderable differences muſt alſo be obſervable in the milk of the ſame animal in different circumſtances, and particularly with relation to the nature of the food which the animal has eat: for we are certain, that milk partakes much of the nature of the aliment uſed by that animal which furniſhes it. *See* Cheese.

The milk of nurſes is well known to acquire the virtues of drugs taken by them; and thus remedies are frequently applied to children at the breaſt. (*c*)

(*c*) Thus the color of ſaffron, the bitterneſs of wormwood, and the ſmell of garlic, are given to the milk of a woman who eats theſe plants; and alſo the purgative and inebriating effects of certain ſubſtances are communicated from the nurſe to the child. Hoffman found by experiments, that the milk of cows and of goats contained more of the butyraceous and caſeous, and leſs of the ſerous and of the ſaccharine particles than human milk, and the milk of aſſes.

CCCCLIII. MILK *of* LIME. MILK *of* SULPHUR. The name of milk is given to ſubſtances very different from milk properly ſo called, and which reſemble milk only in color. Such is water in which quicklime has been ſlaked, which acquires a whiteneſs from the ſmall particles of the lime being ſuſpended in it, and has hence been called the *milk of lime*. *See* QUICKLIME. Such alſo is the ſolution of liver of ſulphur, when an acid is mixed with it, by which white particles of ſulphur are made to float in the liquor. *See* LIVER *of* SULPHUR.

CCCCLIV. MILK *of* VEGETABLES. For the ſame reaſon that milk of animals may be conſidered as a true animal emulſion, the emulſive liquors of vegetables may be called *vegetable milks*. Accordingly emulſions made with almonds are commonly called *milk of almonds*. But beſides this vegetable milk, which is in ſome meaſure artificial, many plants and trees contain naturally a large quantity of emulſive or milky juices. Such are lettuce, ſpurge, fig-tree, and the tree which furniſhes the elaſtic American reſin. The milky juices obtained from all theſe vegetables derive their whiteneſs from an oily matter, mixed and undiſſolved in a watery or mucilaginous liquor. Moſt reſinous gums were originally ſuch milky juices, which afterwards become ſolid by the evaporation of their moſt fluid and volatile parts.

Theſe natural milky juices have not been examined by any chemiſt. Such an examination would, however, procure much eſſential knowledge concerning vegetable economy. We ſhould probably find examples of all kinds of oils reduced into milky juices; and this knowledge cannot fail of throwing much light on the nature of reſins and gum-reſins. *See* GUM-RESINS *and* RESINS.

CCCCLV. MINES. *See* ORES.

CCCCLVI. MINIUM. Minium, or *red lead*, is a calx of lead, of a vivid yellowiſh red color. This color is ſaid to be given by a ſlow calcination and reverberation. Nevertheleſs, the method of making minium is not well known, as it is not made in ſmall quantities in laboratories. All the minium which is in commerce is brought from Holland, where large quantities of it are manufactured.

Minium is employed in painting, and may ſerve for all the ſame purpoſes as the other calxes of lead. *See* LEAD. *(d)*

CCCCLVII. MIRACLE (CHEMICAL). When a concentrated ſolution of fixed alkali is mixed with a ſtrong ſolution of nitre or of ſea-ſalt, with earthy baſes, the earth is ſo copiouſly precipitated, that a ſolid maſs is formed from the mixture of theſe two liquors. As this experiment is ſomething wonderful, it has been called by ſome chemiſts ***miraculum chemicum***. *See* MAGNESIA.

(d) Minium is generally prepared by expoſing lead to a melting heat till it is converted into a greyiſh calx, which is afterwards ground, and again calcined in an oven or reverberatory furnace, during ſeveral days, with a moderate heat. The action of the flame and of air is ſaid to be neceſſary to produce the red color. For which reaſon, the matter to be calcined is frequently ſtirred during the operation, that its ſurface may be changed, and thus the whole of it expoſed to air and flame. Three parts of lead are ſaid to produce nearly four parts of minium; but if the minium be revived, about $\frac{19}{20}$th parts only of the lead originally employed, will be recovered. A ſmaller quantity of the lead will be recovered by reduction of the minium, if the calcination has been performed more effectually.

CCCCLVIII. **MIXTION.** Stahl and all his ſchool uſe this expreſſion to ſignify the union of the firſt principles in the moſt ſimple compounds. Inſtead of it, we ſubſtitute the terms *combination* and *compoſition*; which *ſee.*

CCCCLIX. **MOLYBDENA.** (e)

CCCCLX. **MORTAR.** A mortar is a chemical inſtrument, very uſeful for the diviſion of bodies, partly by percuſſion, and partly by grinding. Mortars have the form of an inverted bell. The matter intended to be pounded is to be put into them, and there it is to be ſtruck and bruiſed by a long inſtrument called a *peſtle.* The motion given to the peſtle ought to vary according to the nature of the ſubſtances to be pounded. Thoſe which are eaſily broken, or which are apt to fly out of the mortar, or which are hardened by the ſtroke of the peſtle, require that this inſtrument ſhould be moved circularly rather by grinding, or bruiſing, than by ſtriking. Thoſe ſubſtances which are ſoftened by the heat occaſioned by rubbing and percuſſion, require to be pounded very ſlowly. Laſtly, thoſe which are very hard, and which are not capable of being ſoftened, are eaſily pounded by repeated ſtrokes of the peſtle. They require no bruiſing but when they are brought to a certain degree of fineneſs. But theſe things are better learnt by habit and practice than by any directions.

As mortars are inſtruments which are conſtantly uſed in chemiſtry, they ought to be kept of all ſizes and materials; as of marble, copper, glaſs, iron, grittſtone, and agate. The nature of the ſubſtance to be pounded determines the choice of the kind of mortar. The hardneſs and diſſolving power of that ſubſtance are particularly to be attended to. As copper is a ſoft metal, ſoluble by almoſt all menſtruums, and hurtful to health, good artiſts have ſometime ago proſcribed the uſe of this metal. *See* Division *of* Bodies.

One of the principal inconveniences of pulveriſation in a mortar proceeds from the fine powder which riſes abundantly from ſome ſubſtances during the operation. If theſe ſubſtances be precious, the loſs will be conſiderable; and if they be injurious to health, they may hurt the operator. Theſe inconveniences may be remedied, either by covering the mortar with a ſkin, in the middle of which is a hole, through which the peſtle paſſes; or by moiſtening the matter with a little water, when this addition does not injure it; or, laſtly, by covering the mouth and noſe of the operator with a fine cloth, to exclude this powder. Some ſubſtances, as corroſive ſublimate, arſenic, calxes of lead, cantharides, euphorbium, &c. are ſo noxious, that all theſe precautions ought to be uſed, particularly when a large quantity of them is pounded.

(e) Molybdena, or *Black lead,* is a blackiſh friable ſubſtance, unſoluble by acids, capable of reſiſting the moſt intenſe heats in cloſe veſſels. It has been generally conſidered as a talky ſubſtance, and as being apyrous: but from ſome late experiments made by Mr. Quiſt, this ſubſtance appears to be decompoſed by a calcining heat in open veſſels, and even to be almoſt entirely diſſipated or conſumed: and, long before theſe experiments, Dr. Lawſon, in his Diſſertation De Nihilo, had ſhewn that blue inflammable flowers were raiſed from black lead by a violent fire. Mr. Quiſt relates, that having expoſed ſeveral ſpecimens of this mineral to a ſtrong heat on a ſcorifying diſh under a muffle, they emitted ſulphureous fumes and flowers; that from one ſpecimen, one fifth part only of the original weight remained after calcination; and from another ſpecimen, only a twentieth part remained, of a yellow or brown calx, which being treated with inflammable fluxes, yielded ſeven-tenths of its weight of a metallic regulus, which appeared to conſiſt of iron and tin. Mr. Cronſtedt has accordingly claſſed black lead amongſt ſulphureous ſubſtances, and calls it *ſulphur ſaturated with iron and tin.*

Black lead is eaſily diſſolved or mixed with melted ſulphur; and with this mixture ſome pencils are made much inferior to thoſe which are made with ſlips of pure black-lead. Crucibles and portable furnaces are made of black-lead mixed with clay. Black lead is alſo uſed to leſſen the friction of machines, which it does from the fineneſs, the want of tenacity, and a kind of unctuoſity of its particles.

Large mortars ought to be fixed upon a block of wood, ſo high, that the mortar ſhall be level with the middle of the operator. When the peſtle is large and heavy, it ought to be ſuſpended by a cord or chain fixed to a moveable pole, placed horizontally above the mortar: this pole conſiderably relieves the operator, becauſe its elaſticity aſſiſts the raiſing of the peſtle.

CCCCLXI. MOTHER-WATER. *See* WATER.

CCCCLXII. MUCILAGE. Mucilage is a white, tranſparent ſubſtance, which has little or no taſte or ſmell, the conſiſtence of which is thick, ropey, tenacious, and viſcid, when it is united to a certain quantity of ſuperabundant water. It is entirely and intimately ſoluble in water; and it does not appear to contain any diſengaged acid or alkali.

When mucilage is diſſolved in a large quantity of water, it does not ſenſibly alter the fluidity of this liquor; but this water, by evaporation, grows more and more thick, and, laſtly, acquires the viſcous conſiſtence of vegetable glue.

While the evaporation continues, the liquor becomes more and more thick, without loſing any tranſparency; and this evaporation may be continued till the mucilage becomes quite ſolid: it then does not differ from gums. If this evaporation or drying has been made with a heat not exceeding that of boiling water, this mucilage, thus rendered ſolid, and become a gum, may be entirely diſſolved again in water, and may again form a liquid mucilage, as before.

Gums or ſolid mucilages, when well dried and very hard, being expoſed to an open fire, are not liquefied as reſinous matters are; they ſwell, and emit many fumes, which at firſt are watery, then oily, fuliginous, and acrid.

This matter, at the ſame time, becomes black, and is then capable of being inflamed; but not before it is thoroughly dried, and almoſt reduced to the ſtate of coal.

If mucilage or gum be expoſed to diſtillation in cloſe veſſels, nothing but water is obtained, with a heat not ſuperior to that of boiling water; and the matter which remains in the retort ſeems to be nearly of the ſame degree of dryneſs as before the operation; which is a certain proof that diſtillation does only deprive the gum of its ſuperabundant water. If a greater degree of heat be then applied, more aqueous liquor will be obtained, which gradually becomes more and more acid and empyreumatic. By continuing the diſtillation with a fire gradually augmented, a little thick oil and volatile alkali paſs; and, laſtly, a conſiderable quantity of reſiduous coal remains in the retort, which burns difficultly in open air; together with ſome aſhes, from which a very little fixed alkali may be obtained.

Mucilages and gums are not ſoluble either by oils, or by ſpirit of wine; which latter menſtruum has the property of taking from theſe ſubſtances the water in which theyare diſſolved; ſo that if ſpirit of wine be mixed with a liquid mucilage, or with water in which gum is diſſolved, this ſpirit will take all the water of the ſolution, and will ſeparate the gummy matter in form of an almoſt dry white precipitate. We may eaſily perceive that this experiment cannot ſucceed but by adding a ſufficient quantity of ſpirit of wine, that is, a quantity proportionable to the quantity of water united with the gummy matter.

From what we have ſaid concerning the general properties of the gummy vegetable principle, we may conclude, firſt, that excepting a portion of ſuperabundant pure water, no ſubſtance is contained which is volatile with the heat of boiling water; conſequently no volatile ſaline ſpirits, no eſſential oil, or ſpiritus rector, at leaſt in any ſenſible quantity.

Secondly, we may conclude, that this gummy matter is compoſed, firſt, of a certain quantity of oil of the nature of ſweet oils, which are not volatile, nor ſoluble in ſpirit of wine; ſecondly, of water; thirdly, of vegetable acid; and, laſtly, of an attenuated earth; that the oil which is a principle of gums is in ſmall quantity, ſince they are not attackable by oily or ſpirituous ſolvents; and that they are difficultly combuſtible.

Thirdly, that the portion of oil which is combined in gums is in them ſo intimately united with a ſufficient quantity of acid, that it is rendered entirely ſoluble in water.

Fourthly, that as all compounds, the principles of which are nearly in theſe proportions, and in this kind of union, are ſuſceptible of fermentation, all gummy matters are fermentable; they are alſo nutritive. This is confirmed by experience. Some differences, however, exiſt in this reſpect betwixt the ſeveral mucous vegetable matters. Some of them, particularly thoſe called *gums*, are very tranſparent, inſipid, little nutritive, and ſuſceptible of only an imperfect fermentation, which paſſes ſoon to vapidity or mouldineſs: others, namely thoſe which all the farinaceous ſubſtances furniſh, are leſs tranſparent, leſs inſipid, more viſcid, more nutritive, and ſuſceptible of a compleat ſpirituous fermentation, particularly when they are placed in circumſtances favorable to fermentation. *See* BEER.

Although the exiſtence of mucilage in all vegetables and in all their parts is not equally ſenſible, we may nevertheleſs conſider it as univerſally diffuſed through the vegetable kingdom. Plants, or the parts of plants, from which no mucilage is obtainable by ordinary proceſſes, do all impregnate water with an extractive matter; and this extractive matter includes always a certain quantity of mucilaginous ſubſtance, which remains mixed with the ſaline and ſaponaceous matters, and which might even be ſeparated by certain proceſſes, particularly by a proper application of ſpirit of wine.

The uſe of the mucilaginous matter appears to be in the vegetable kingdom exactly the ſame as that of the gelatinous matter in the animal kingdom. Theſe two ſubſtances, which, in many reſpects, reſemble each other, are both of them ſingularly nutritive and reparative.

Accordingly, nature has provided all the plants which have occaſion for it with plenty of it; and has even produced a ſuperabundant quantity of it for the encreaſe and ſupport of each individual. This ſuperabundance of nutritive matter is reſerved with economy in vegetables, as in animals, for the generation and reproduction of individuals of the ſame ſpecies.

The ſeed and eggs of animals are then nothing elſe than a proviſion of gelatinous matter, intended for the production and nutrition of their young. The ſame obſervation is applicable to all the ſeeds and kernels of vegetables, which may be conſidered as their eggs; all which contain ſo much mucilage, that it may be eaſily obtained abundantly from them by infuſion or boiling in water.

Some of theſe, ſuch as the ſeeds called emulſive, furniſh eaſily by infuſion in water a conſiderable quantity of the kind of mucilage which we mentioned above was tranſparent, not very nouriſhing or viſcid; but they alſo contain a conſiderable quantity of ſweet oil, which may be obtained by expreſſion alone. The others, thoſe called *farinaceous grains*, being bruiſed and boiled in water, are almoſt entirely reduced to a glue, which is nothing elſe than the kind of mucilage which we mentioned as being very nutritive. Theſe grains do not, like the emulſive ſeeds, contain an expreſſible oil; but a conſiderable quantity of oil enters into the compoſition of the mucilage. Accordingly, theſe two kinds of ſeeds contain the ſame materials, with this difference, that a large portion of ſweet oil is diſengaged in the emulſive ſeeds, and is combined in the farinaceous grains.

The kind of grains called *leguminous*, which are very numerous, contain a meal more mucilaginous than thoſe properly called farinaceous; but they are likewiſe provided with a greater or leſs quantity of ſapid or even ſaccharine ſubſtance, which alſo is a kind of mucilage, and of a truly nutritive nature. *See* SUGAR.

The roots of many plants are filled with much mucilage or ſaccharine matter. Some of them are farinaceous; eſpecially thoſe which produce the entire plant.

Mucilage is eaſily obtained from the vegetable ſubſtances above-mentioned, by infuſing or ſlightly boiling in water thoſe which contain it moſt abundantly, as linſeed, the ſeeds of pſyllium, of quinces, the roots of marſhmallows, &c. The water by this means ſoon becomes ropey and viſcous, like the whites of eggs. The water and heat neceſſary for this extraction are incapable of cauſing any alteration upon the mucilages, which are therefore obtained exactly in the ſame ſtate as in the vegetable itſelf.

From many trees much mucilage iſſues ſpontaneouſly, which being dried by the air and ſun, forms gums. Theſe trees are chiefly the acacia, the almond, the peach, the apricot, the plumb, and even the pear and apple-trees. May not this exſudation of nutritive ſubſtance, which might be conſidered as the effect of a ſuperabundant quantity of nutritive juice, rather proceed from a ſtoppage or too great fulneſs of the veſſels containing it? That this exſudation proceeds from a diſeaſe in the tree, is rendered probable by this remark, that all the trees from which much gum iſſues, become languid and dry, and do at length periſh, with all the appearances of trees which die from want of nouriſhment.

Gummy and mucilaginous matters ſerve for many different purpoſes. Gums are employed in the arts, in dyeing, in painting with water-colors, and for giving luſtre and firmneſs to ſtuffs.

Mucilages are the moſt relaxing, emollient, and ſoftening remedies in medicine. But if we take the term *mucilaginous matter* in its moſt extenſive meaning, and apply it, as we may with propriety, to all the farinaceous and ſaccharine vegetable ſubſtances, then the above-mentioned advantages are nothing in compariſon of their infinite utility to us, ſince that ſubſtance conſtitutes the chief and ſole matter of our nouriſhment, whether we obtain it directly from the grains and roots of vegetables which we eat, or that it has previouſly ſerved as food to the animals which we uſe as food.

CCCCLXIII. MUFFLE. *See* VESSELS (CHEMICAL).

CCCCLXIV. MUSK. *(f)*

CCCCLXV. MUST. By *muſt* is meant the ſaccharine juice of ſeveral fruits ſuſceptible of the ſpirituous fermentation, and particularly of grapes, before the commencement of this fermentation. Accordingly, muſt is, properly ſpeaking, what is commonly called *ſweet wine*. *See* JUICES (SACCHARINE) *and* WINE.

CCCCLXVI. MYRRH. *(g)*

(f) MUSK is an animal juice, the moſt odoriferous of all known ſubſtances. Its ſmell is very diffuſive, and adheres very tenaciouſly to ſubſtances perfumed with it. From thirty grains, water extracted twelve grains, and from the ſame quantity, ſpirit of wine extracted ten grains. Spirit of nitre and oil of vitriol totally diſſolve it. The former deſtroys the whole of its ſmell, and the latter the greateſt part of it. Spirit of ſalt, dilute ſpirit of vitriol, and vinegar, have no effect upon it. Spirit of ſal ammoniac diſſolves a little of it. Oil of tartar ſcarcely acquires any tinge from muſk, but extricates from it a volatile urinous ſmell. Muſk is not ſoluble in oils expreſſed or diſtilled. By diſtillation in a retort, musk yielded the animal principles, empyreumatic oil, volatile ſpirit and ſalt. Musk is uſed medicinally, and as a perfume. In the diſtillation of odoriferous waters and ſpirit, a ſmall portion of musk included in a linen cloth, is generally hung in a ſtill-head, the vapors of both liquors extracting its ſcent Spirit diſtilled with musk immerſed in it acquires little of its ſmell. But water by this method acquires both the ſmell and taſte. A minute portion of musk greatly improves the fragrance of the diſtilled odoriferous waters, as thoſe of lavender and roſemary, and heightens the ſmell of other odoriferous ingredients, without communicating any of its own peculiar ſmell. *Neuman.*

(g) MYRRH is a gum reſin, from ſixteen ounces of which twelve ounces and a half were extracted by water, and from the ſame quantity five ounces were extracted by ſpirit of wine. The whole ſmell and taſte of the myrrh is received either by the water, or by the ſpirit, and the reſiduous ſubſtances are perfectly inſipid. By evaporating the aqueous infuſion, an extract is obtained, containing all the bitterneſs, but not the flavor of the myrrh, which ſeems to reſide in an eſſential oil; three drams of which may be obtained by diſtillation of a pound of myrrh. If ſome powdered myrrh be incloſed in the white of a hard boiled egg, and ſet in a moiſt cellar, the liquor into which the egg will be gradually reſolved, will extract nearly all the ſmell and taſte of the myrrh. This liquor, which is commonly called, *oil of myrrh per deliquium*, may be precipitated and coagulated by ſpirit of wine. This coagulum is ſoluble by water.

N.

CCCCLXVII. NAPHTHA. This name is given to the petroleum which is the moſt white, volatile, and thin, whether this bituminous matter poſſeſs theſe qualities naturally, or has acquired them by rectification. *See* PETROLEUM *and* BITUMENS. *(h)*

CCCCLXVIII. NATRUM *or* NATRON. This is a native alkaline ſalt of the nature of the mineral or marine alkali, which is found cryſtallized in Egypt, and in ſome other hot countries, in ſands which ſurround lakes of ſalt water. This cryſtallization is produced by the ſpontaneous evaporation of this water; and as that water contains other ſalts alſo, beſides the mineral alkali, the natrum is not a pure mineral alkali, and is naturally found mixed with other ſaline matters, and particularly with common ſalt. This ſalt is ſaid to be the nitre of the ancients. It is little known in this country. The ſoda, and ſalt obtained from it, being of the ſame nature as the natrum, ſupply all our purpoſes. *See* ALKALI (MINERAL).

CCCCLXIX. NEPHRITIC STONE. *(i)*

CCCCLXX. NEPHRITIC WOOD. *(k)*

(h) Mr. Rouelle thinks that naphtha is formed by a diſtillation of bitumens occaſioned by ſubterranean fires.

(i) NEPHRITIC STONE. This is a green, ſemi-tranſparent, foliated ſtone, unctuous to the touch, not compact, nor capable of being poliſhed. By Wallerius it is ranked amongſt gypſums; and by Pott, amongſt calcareous earths. Some other authors more juſtly conſider it as a ſteatites, from its unctuoſity, from its partial ſolubility in acids, and from its property of becoming hard by burning. Its green color is occaſioned by copper, a ſmall quantity of which metal Mr. Pott extracted from this ſtone, by fuſion with borax. Neuman affirms, that by diſtilling the ſtone, he obtained a ſmall portion of an empyreumatic oil, and of an ammoniacal ſalt.

(k) NEPHRITIC WOOD. This wood gives a blue color to ſpirit of wine, or to water. This color is changed to a yellow by acids, and afterwards reſtored to a blue by alkalis. Dr. Lewis obſerves, that it is the only woody matter which gives a blue tincture; and that this is the only vegetable blue which is thus deſtructible by acids.

CCCCLXXI. NICKEL. *(l)*

CCCCLXXII. NITRE, *or* SALTPETRE. Nitre is a neutral ſalt compoſed of a peculiar acid, called *nitrous acid*, ſaturated with fixed vegetable alkali.

This ſalt has a ſaline and cooling taſte, which is ſucceeded by another more diſagreeable taſte. It is eaſily ſoluble in water, but in much greater quantity in boiling than in cold water. It is conſequently one of thoſe ſalts which are more readily cryſtallized by cold than by evaporation. Therefore, if fine cryſtals of nitre are required, this ſalt muſt be diſſolved in water, and heat muſt be applied, that the water may take up more ſalt than it can retain when it is cold. When this ſolution of nitre is allowed to cool, many cryſtals will be formed which will be ſo much larger and finer, as the quantity of ſalt operated upon at the ſame time has been greater, and as the cooling of the liquor has been ſlower.

Cryſtals of nitre are oblong ſolids, the large faces of which are parallel. They are kinds of priſms furrowed by parallel and longitudinal grooves.

The acid and alkali, of which nitre conſiſts, are united together ſo intimately, that it may be conſidered as a perfect neutral ſalt. It is not deliqueſcent, but it retains ſtrongly the water of its cryſtallization, by which its tranſparency is preſerved even in a dry air, and it does not effloreſce, or become mealy.

Nitre is one of the moſt fuſible ſalts. It is liquefied by a heat much leſs than what is neceſſary to make it red, and remains thus in tranquil fuſion without ſwelling. If nitre thus melted be left to cool and fix, whether it has been made red-hot or not in this fuſion, it coagulates into a ſolid, ſonorous, ſemi-tranſparent maſs, and is then called *mineral cryſtal*. This melted nitre, or mineral cryſtal, has, excepting the arrangement of the cryſtallization, all the ſame properties as cryſtallized nitre. Mr. Beaumé obſerves, that nitre loſes by fuſion little, if any, of the water of its cryſtallization, ſince the weight of the mineral cryſtal is nearly the ſame as the weight of the nitre employed.

(l) NICKEL is a ſemi-metal, firſt deſcribed by Mr. Cronſtedt, in the Swediſh Memoirs for the years 1751 and 1754. The properties there attributed to it are, 1. That it is of a white color, inclining to red. 2. Its texture is ſolid, and ſhining in its fractures. 3. Its ſpecific gravity is to that of water as 8500 to 1000. 4. It is conſiderably fixed in the fire. 5. It is calcinable, and its calx is green. 6. This calx is not very fuſible, but it nevertheleſs tinges glaſs of a tranſparent reddiſh brown, or jacinth color. 7. It diſſolves in aqua fortis, aqua regia, and marine acid, but difficultly in vitriolic acid. All theſe ſolutions have a deep-green color. The vitriol formed of it is alſo of the ſame color; and the colcothar of this vitriol, and alſo the precipitates from the ſolutions, are rendered by calcination of a light green color. 8. Theſe precipitates are ſoluble by ſpirit of ſal ammoniac, and the ſolution has a blue color. But no copper can be produced by a reduction of the precipitates. 9. It ſtrongly attracts ſulphur. 10. It unites with all metallic ſubſtances, excepting ſilver, quickſilver, and zinc. Its attraction to regulus of cobalt is the ſtrongeſt, next to which is that to iron, and then to arſenic. 11. It retains its phlogiſton a long time in the fire, and its calx is reducible by a very ſmall quantity of inflammable matter. It requires, however, a ſtrong red heat before it can be fuſed, and melts a little ſooner, or as ſoon as, gold or copper. Nickel is contained in the reddiſh-yellow mineral, called *Kupfer-nickel*, which, beſides nickel, contains alſo iron, regulus of cobalt, arſenic, and ſulphur.

Hence the liquefaction of the nitre, even at firſt, ought not to be attributed to the water of its cryſtallization, as is the caſe with Glauber's ſalt and many other ſalts, but is a true fuſion from the beginning; and this fuſibility of nitre is cauſed by the water which enters into its compoſition as a ſalt, and not merely as a cryſtallized ſalt. Accordingly, mineral cryſtal is as fuſible as nitre itſelf. The fuſibility of nitre may alſo probably depend conſiderably on the inflammable principle which enters its compoſition, and particularly the compoſition of its acid. *See* Acid (Nitrous).

When nitre is kept in fuſion with a moderate heat, while at the ſame time it does not touch any inflammable matter, nor even flame, it remains in that ſtate without ſuffering any very ſenſible alteration. But if it be kept in a ſtrong fire, it becomes more and more alkaliſed, becauſe then the flame or burnt phlogiſton penetrates it, even through the crucible, ſufficiently to deſtroy the acid of the ſalt. *See* Acid (Nitrous), *and* Detonation *of* Nitre.

From this property of being alkaliſed by a ſtrong heat alone, it aſſiſts the fuſion and vitrification of flints and ſands as pure alkalis do. A conſiderable part, nevertheleſs, of the nitrous acid may poſſibly remain in the vitrified ſubſtances, or may even contribute to the fuſion. *See* Vitrification.

All theſe ſubſtances, which contain phlogiſton fixed in a certain degree, and which are nevertheleſs combuſtible, being made red-hot and applied to nitre, accelerate greatly the alkaliſation of this ſalt, and render it compleat, if theſe ſubſtances be in ſufficient quantity; and reciprocally, nitre accelerates much and compleats the calcination or combuſtion of theſe ſubſtances, becauſe its acid aſſiſts the burning of their phlogiſton, and burns itſelf along with this inflammable principle.

This alkaliſation is made with or without any ſenſible detonation, according to the ſtate, the quantity, and the greater or leſs intimacy of the mixture of the inflammable matters. And the nitre thus decompoſed or alkaliſed is frequently called *nitre fixed* by ſuch or ſuch ſubſtance; for inſtance, *nitre fixed by tartar*; *nitre fixed by coals*. when it is alkaliſed by tartar or by coals. This name of *fixed nitre* is improper: for when the operation is finiſhed, the reſiduum contains nothing nitrous, but only the alkali of nitre, with the aſhes or earth of the inflammable matter employed for this alkaliſation.

The phenomena which nitre exhibits, when it is decompoſed by means of phlogiſton, are numerous and intereſting The detail and explanation of them may be found under the article Detonation *of* Nitre.

Nitre is capable of being decompoſed by ſeveral other ſubſtances. Theſe are, pure vitriolic acid; vitriolic acid engaged with an earthy or metallic baſe; ſedative ſalt; arſenic; and phoſphoric acid. But none of theſe ſubſtances acts upon nitre in the ſame manner as phlogiſton does. They do not, like phlogiſton, deſtroy its acid, but only diſengage and ſeparate it from its alkali. Hence it follows, 1. That after the decompoſition of nitre by means of theſe ſaline ſubſtances, its alkali does not remain alone, but a combination of this alkali with the ſubſtance employed for the decompoſition. 2. If we make the operation in veſſels proper for diſtillation, the nitrous acid which has been ſeparated during the operation from its alkali may be obtained. For the detail of theſe operations ſee the words, Spirit *of* Nitre, Salt (Neutral Arsenical), Salt (Sedative), *and* Phosphorus.

Nature furniſhes us with a very ſmall quantity of nitre ready formed, in compariſon of the quantities which are employed. Nitre is found naturally cryſtalliſed in India, and as it is ſwept from earths or ſtones with brooms, it is called the *ſweepings of nitre* or *of ſaltpetre*. A nitre may be obtained from ſeveral plants. Theſe are the two kinds of natural nitre. All other nitre is only begun by nature, and is found in the walls of old buildings. Art is required to compleat it, to extract it, and to purify it, as we ſhall proceed to explain, after having made ſome reflexions on the generation of this ſalt.

As neither nitre nor nitrous acid, engaged in any baſe whatever, is any where found collected from time immemorial in great quantities, as the vitriolic and marine acids are, but is only found produced from time to time in places where not an atom of this ſalt exiſted; it evidently appears to be habitually produced by the concurrence of circumſtances favorable to its formation.

Some chemiſts and naturaliſts believe, that becauſe nitre is commonly obtained from ſubſtances long expoſed to air, that nitrous acid exiſted ready formed, like the other two mineral acids, and that it is ſucceſſively depoſited in matters proper for its reception. But this opinion is quite rejected, particularly by chemiſts, ſince they have been aſſured from experience, that by a long expoſure of the moſt proper ſubſtances for the reception and retention of nitrous acid, as fixed alkali, to the air, no nitre is ever obtained. Cloths ſoaked in fixed alkali, and expoſed to air by hanging freely, are indeed at length filled with cryſtals of a neutral ſalt; but this is vitriolated tartar, and not nitre.

On the other ſide, we are certain that nitre or nitrous acid, engaged in any baſe, is never found but in places capable of being impregnated with vegetable or animal juices. Hence, it is never found in any place inacceſſible to theſe matters, as in very great heights or deeps.

Mr. Lemery the younger conſidering theſe things, and that nitrous ſalts or perfect nitre are obtained by analyſing many vegetable and animal matters, has concluded from thence, that this ſalt exiſts naturally ready formed in the individuals of theſe two kingdoms, which are, according to him, the only ſource of it. In the Memoirs he has given upon this ſubject, he explains how nitre, or rather nitrous acid, which is either at firſt not perceptible, or in ſmall quantity, in animals and vegetables, may be afterwards unfolded by the action of the air, and by the fermentation excited in theſe compound bodies as ſoon as their life ceaſes.

But this opinion, although ſpecious, is liable to great difficulties; for vegetables and animals are not permanent beings, but are continually produced and deſtroyed. The peculiar ſubſtances then, of which they are compoſed, conſiſt of principles extracted from the air and the earth. We may therefore object to Mr. Lemery, that the nitre found in animals and vegetables is extraneous to them, and proceeds originally from the air and the earth.

This objection is ſupported by a well known fact, namely, that the moſt nitrous plants contain very unequal quantities of it, according to the quantity of the nitre which is contained in the ſoil or earth in which they grow. Beſides, vegetable and animal ſubſtances may be putrified without affording a larger quantity of nitre, unleſs it has been expoſed to the air and mixed with earthy and ſtoney matters. Vegetable and animal matters contain the nitre or nitrous acid ready formed, only *accidentally*; they do not even always contain all the materials neceſſary for its production: and all that we can infer is, that the concurrence of animal and vegetable matters is neceſſary for this production of nitre.

The third opinion concerning the origin of nitre is that of Stahl. This chemiſt, who thought, with Becher, that the vitriolic is the only original acid, and that from this all other acids are produced, believed that the nitrous acid is only the vitriolic acid metamorphoſed by the union it contracts with ſome other principle. This principle, according to him, is phlogiſton: and putrefaction is the method employed by nature to combine this acid with the inflammable matter of putrifying ſubſtances, in the convenient proportion and manner for giving to it the ſpecific character of nitrous acid.

This is the moſt probable opinion of all. For without conſidering the analogies which are obſervable betwixt the nitrous and the volatile ſulphureous acids, moſt of the circumſtances attending the origin of nitre ſeem to be further proofs of it.

Firſt, the atmoſphere appears to contain the vitriolic acid, or ſome matter in which it exiſts, and from which it is depoſited in proper baſes.

Secondly, nitre is never found but in earths or ſtones which have been impregnated with vegetable or animal juices, and theſe juices muſt have remained a ſufficiently long time to have ſuſtained the whole putrefactive proceſs.

Thirdly, Meſſrs. Mariote and Lemery have expoſed to pure air, during a long time, earths and ſtones very fertile in nitre, after having deprived them of all their contents, and no nitre was formed in them, becauſe they had not again imbibed any vegetable or animal juices.

Laſtly, the Academy of Sciences at Berlin, having propoſed ſome years ago, for the ſubject of their annual prize, to determine the origin and principles of nitre, Dr. Pietchs, who obtained the prize, ſays in his Diſſertation, that having ſoaked with urine and vitriolic acid a calcareous ſtone, and having afterwards expoſed it to the air during ſome time, he found it afterwards full of nitre. This experiment is favorable to Stahl's opinion, which Mr. Pietchs adopts in his Memoir.

One part indeed of the obſervations which we have related agrees alſo with Mr. Lemery's opinion. But whether nitre be produced in vegetables and animals during their life, as Lemery believes; or whether a part of the principles of theſe ſubſtances combines afterwards with the vitriolic acid diffuſed in the air, or pre-exiſting in earths and ſtones, as Stahl ſays; this may certainly be inferred, that nitre does not exiſt ready formed, and in great quantities in nature, as the vitriolic and marine acids are, but that it is generated and produced from time to time by the concurrence of circumſtances favorable to its formation.

We may obſerve upon the ſubject of the principles and production of the nitrous acid, that as we have ſhewn that putrefactive matters are requiſite to its formation, and as vegetable and animal ſubſtances are only ſuſceptible of putrefaction, this acid therefore belongs equally to the three kingdoms of nature.

Nitrous acid is not commonly found diſengaged: neither is it generally united with any one particular baſis, as marine acid is; but it is no ſooner generated, than it combines with any matters which it can diſſolve, and which are within its reach. Accordingly, it is ſometimes united with a fixed alkali, and conſequently forms ordinary nitre; ſuch are what are called the ſweepings of nitre and the nitre of plants; but moſt frequently it is combined with abſorbent earths, becauſe it generally meets theſe in places where it is formed moſt copiouſly: it is, therefore, moſt generally found in the form of nitre with an earthy baſis.

The moſt favorable places for the production of nitre are the habitations of men and animals, and particularly ſuch as are low and moiſt, as cellars, kitchens, ſtables, houſes of office, and others of that kind, which are apt to to be impregnated with vegetable and animal matters, and alſo to have an habitual moiſture, which is favorable to putrefaction; and, laſtly, which are ſheltered from rain, which might otherwiſe diſſolve and carry off the nitre as ſoon as it is formed.

Theſe buildings are true nitre-beds. When they are old, their rubbiſh and plaſter are full of nitre: but this nitre is only a nitre with an earthy baſis, which is not ſuſceptible of cryſtallization or detonation, which are the two eſſential qualities in nitre for the principal uſes, to which it is applicable, and which it cannot poſſeſs but by being joined to a baſis of fixed alkali. Beſides, the nitre of rubbiſh is mixed with much common ſalt, which comes alſo from the vegetable and animal matters, and from ſome heterogeneous ſubſtances, which alter its purity. The chief intention, therefore, of the operation upon rubbiſh, to obtain a perfect nitre, is to furniſh this ſalt with a baſis of fixed alkali, and to diſengage it from the heterogeneous matters which alter its purity. Theſe views are accompliſhed in the following manner.

The rubbiſh containing nitre is to be broken to ſmall pieces, and mixed with nearly an equal quantity of wood-aſhes. This mixture is to be put into caſks ranged along each other, placed vertically on one of their ends, and ſupported at the height of two feet above the ground. At the bottom of each caſk is a hole, filled with ſtraw. Water is to be poured into the firſt caſk; and this water, when impregnated with all the ſaline matter in the mixture, flows into a bucket placed under the caſk for its reception. This ſame water is poured ſucceſſively into the other caſks, and thus becomes impregnated with more and more ſaline matter. The makers of ſalt-petre obſerve always to paſs the ſtrongeſt lixiviums through caſks filled with new matter; and before they throw away the matter of a caſk when almoſt exhauſted, they paſs through it the firſt water yet unimpregnated. By theſe operations, which are well contrived, they obtain a lixivium as much impregnated as it can be, and they at length entirely exhauſt the rubbiſh of all the nitre it contained.

The lixivium of nitre thus prepared is carried to great copper cauldrons, in which it is boiled and evaporated, till it is ſufficiently ſtrong for the cryſtallization of the ſalts. As the two cryſtallizable ſalts contained in this lixivium are nitre and common ſalt, and as the latter of theſe ſalts is cryſtallizable by evaporation only, and the ſecond by cold only; the common ſalt cryſtallizes firſt during the evaporation, and forms ſmall cubical cryſtals which ſubſide to the bottom of the cauldron. The ſalt-petre-makers call it the *grain*. They take it out with large ladles, and put it in a baſket hung over the cauldron to drain. This evaporation is continued, and the grain is to be taken away as faſt as it is formed, till the liquor be ſo much evaporated, that, when it is cold, much nitre will be cryſtallized in it; and in order to diſcover when it is ſufficiently evaporated for that purpoſe, a ſmall quantity of it is to be taken out from time to time. When they perceive, upon cooling the liquor, that a ſufficient quantity of nitre is formed in it, they remove the liquor from the cauldron into large copper baſons, which they carry to a place deſigned for the cryſtallization.

As this liquor contains much nitre, and as it is quickly cooled, the greateſt part of the ſalt is coagulated at the bottom of the baſons in unſhapely maſſes, compoſed of many ſmall needle-like cryſtals of nitre, and ſometimes of large regular cryſtals upon their ſurfaces. Theſe are called *ſticks of nitre.*

In the baſons remains a large quantity of liquor, the nitre contained in which cannot be cryſtallized but by a ſecond evaporation, which is therefore performed in the ſame manner as at firſt, and more nitre is obtained. This operation is repeated till no more nitre can be formed by cooling the evaporated liquor, which then becomes very red and acrid, and is called the *mother-water of nitre.*

This mother-water is compoſed almoſt entirely of nitre and common ſalt with earthy baſes, which certainly proceed from too ſmall a quantity of aſhes having been mixed with the lixivium of the nitrous rubbiſh. This mother-water may therefore be avoided, by mixing a ſufficient quantity of aſhes with the nitrous rubbiſh, to decompoſe all the ſalts with earthy baſes which it contains; and thus, after the ſeveral evaporations and cryſtallizations, nothing would remain but a ſmall quantity of red liquor impregnated with unctuous matter.

When only the uſual quantity of aſhes is employed, the baſis of the earthy ſalts contained in the mother of nitre may be precipitated by adding an alkaline lixivium. This precipitate is white, and is called the *magneſia of nitre*; and, at the ſame time, the nitre with earthy baſis in the mother-water, being changed into a nitre with baſis of fixed alkali, is eaſily obtainable by cryſtallization: but the ſalt-petre-makers do not employ any of theſe methods with their mother-water, which they throw upon the nitrous rubbiſh after it has been exhauſted of its ſalt by lixiviation. Some time afterwards, they lixiviate this rubbiſh in the ſame manner as they did at firſt, that is, with the addition of aſhes, and obtain from it more nitre. We may eaſily perceive that this operation is preciſely upon the ſame principles as one of thoſe we have propoſed. *See the words* WATER (MOTHER), NITRE *with* EARTHY BASIS, SALT (COMMON) *with* EARTHY BASIS.

The nitre obtained by theſe cryſtallizations is red, and ſoiled by the liquor in which it was diſſolved, which has alſo that color. Further, although common ſalt does not cryſtallize by cold alone, yet a certain quantity of it always cryſtallizes along with the nitre; both becauſe the evaporation continues while the liquor cools, and becauſe the nitre, during its cryſtallization, always takes with it a portion of common ſalt.

This nitre, which the manufacturers call *nitre of the firſt boiling*, is therefore impure, and mixed with common ſalt, and with ſalts with earthy baſes, by which it is rendered unfit for many of the uſes to which nitre is applied, as we ſhall afterwards ſee. It is purified by diſſolving it in pure water, and by proceeding to a ſecond cryſtallization by cold; and as in this ſecond cryſtallization, the proportion of nitre to common ſalt, and to ſalts with earthy baſes, is infinitely greater than at firſt, ſo that when the liquor is at the point of the cryſtallization of the nitre, it is very far from being ſo much evaporated that the common ſalt can cryſtallize at that time; and therefore the nitre obtained in this ſecond operation is infinitely purer than that of the former. It is alſo white, and is called by the manufacturers *nitre of the ſecond boiling*. This is the nitre employed by diſtillers of aqua-fortis, for the ordinary aqua-fortis.

But this nitre is not yet ſufficiently pure for the preparation of good gunpowder; and it muſt therefore be purified by a third boiling or cryſtallization. This is the pureſt nitre that is ſold, or that is kept in arſenals. It is very beautiful and white: but it is not yet ſufficiently pure for certain delicate operations in chemiſtry, and muſt therefore undergo a fourth purification. For the underſtanding of the theory of the operations for the extraction and purification of nitre, *ſee the article* CRYSTALLIZATION *of* SALTS.

All nitrous earths and ſtones which are found, contain alſo a conſiderable quantity of common ſalt. The late Mr. Petit, who has given, in the Memoirs of the Academy of Sciences, a good deſcription of the manufactory of ſalt-petre, ſays, that the quantity of common ſalt contained in the materials is nearly a fourth part of the quantity of nitre. It is even probably more, if we comprehend the common ſalt with earthy baſis contained in the mother water of nitre.

This common ſalt is depoſited in the nitrous earths and ſtones by the vegetable and animal juices which are neceſſary to the generation of nitre, all which contain more or leſs common ſalt. The exiſtence of this common ſalt in all nitrous ſubſtances has induced ſome chemiſts to believe that the marine acid was converted into the nitrous. I have heard that a certain perſon had the ſecret of tranſforming common ſalt into nitre, and that he had propoſed to furniſh nitre at a cheap rate. A more particular examination of this matter deſerves to be made by chemiſts.

No uſe is made in France of the common ſalt in the manufacturing of ſalt-petre. The farmers-general oblige the manufacturers to give an exact account of it, and to throw it into the river. The purification of it would be difficult; becauſe, during the making of the ſalt-petre, a febrifugal ſalt of Sylvius is formed, by the union of the vegetable alkali of the aſhes, with the acid of the marine ſalt with earthy baſis; and becauſe the ſalt of Sylvius has all the properties of common ſalt, only that its taſte is very diſagreeable.

The uſe of nitre is very extenſive in medicine, and in the arts, and in chemiſtry. Perſons who know little of chemiſtry muſt be ſurprized that this ſalt, ſo inflammable, ſhould be employed in medicine as a powerful diuretic, ſedative, and cooler; which virtues it certainly poſſeſſes. It is daily preſcribed by the moſt ſkillful phyſicians, from ten or twelve grains to half a dram, in ſome proper drink. It might be given without danger in a much more conſiderable quantity; for this ſalt, which is perfectly neutral, is very mild; but it has been obſerved to produce its intended effects better when it is given in the above-mentioned quantity only. (*m*)

(*m*) Some curious experiments concerning the effects of nitre taken internally are related in *Mr. Alexander's Experimental Eſſays.* From theſe it appears, that nitre has a power of almoſt inſtantly retarding the velocity of the circulation of the blood, and of ſurpriſingly diminiſhing the number of arterial pulſations; and that its effects are much more powerful, when newly diſſolved in water, than when it had remained diſſolved during ſome hours. As this difference muſt have proceeded from the cold, which is pro-

Beſides the nitrous acid obtained from nitre, which is one of the moſt powerful agents in chemiſtry, nitre itſelf is alſo uſed in many chemical operations. Its properties of detonating with bodies containing phlogiſton, of accelerating their calcination, and particularly the calcination of the imperfect metals, render it uſeful for the purification of gold and ſilver when they are allayed with other metals. As nitre is quickly and eaſily alkaliſed, it enters into the compoſition of reducing fluxes, or of ſimple fluxes, to aſſiſt fuſion and vitrification. Laſtly, by its detonation it may be employed to diſcover the preſence of the inflammable principle in ſubſtances.

But the moſt conſiderable uſe and conſumption of nitre is in the preparation of gun-powder, of which this ſalt makes a great part; and for this purpoſe it muſt be very pure. *See* Powder (Gun), *and* Powder (Fulminating).

CCCCLXXIII. NITRE (ALKALISED.) This is the fixed alkali which remains after the nitrous acid has been deſtroyed by its detonation with any inflammable matter. This alkali is generally called *fixed nitre*. *See* Nitre (Fixed).

CCCCLXXIV. NITRE (AMMONIACAL). This is a neutral ſalt reſulting from the combination of the nitrous acid, to the point of ſaturation, with volatile alkali. *See* Ammoniacal (Nitrous) Salt.

CCCCLXXV. NITRE (CALCAREOUS), or NITRE *with* EARTHY BASIS. Calcareous nitre is a neutral ſalt compounded of the nitrous acid combined to ſaturation with a calcareous earth. It is generally called *nitre with an earthy baſis*, becauſe the ſalts formed by the nitrous acid with the other earths have not been attended to.

Nitrous acid diſſolves with great activity all calcareous earths and ſtones, calcined or uncalcined. It diſſolves a large quantity of them, and leaves no reſiduum when they are pure. By this combination is formed a neutral ſalt very deliqueſcent. This ſalt is not ſuſceptible of a true cryſtallization. It has a poignant, acrid, and bitter taſte. If it be evaporated to dryneſs, it becomes ſolid, and ſeems to be an earthy matter, which does not detonate, or at leaſt very weakly, with inflammable matters.

All theſe properties of nitre with an earthy baſis proceed from the weak adheſion of its acid to the earth. This adheſion is ſo weak, that if the ſalt be diſtilled in a retort, an acidulous phlegm will firſt paſs over; and when the fire is encreaſed, all the acid will follow, excepting a ſmall portion which adheres more ſtrongly, but which may be at laſt expelled by calcination in an open fire.

Mr. Pott, who has particularly examined the combination of nitrous acid with quicklime, ſays, that this acid ſuffered remarkable alterations by diſtillation from quicklime, and by repeated cohobations. By theſe experiments he obtained a nitrous ſalt more ſenſibly ſuſceptible of cryſtallization and detonation than ordinary nitre with earthy baſis; which is very remarkable, and may induce us to ſuſpect that a part of the nitrous acid, and of its inflammable principle, might combine with the quicklime, ſo as to give it the character of

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duced by nitre during its ſolution, probably a much greater effect would be produced by procuring that ſolution in the ſtomach. A remarkable inſtance is given in that book of a ſudden ſwelling over the whole body of a woman, and other dangerous ſymptoms, which were occaſioned by her ſwallowing a ſolution of nitre in water, by miſtake, inſtead of Glauber's ſalt.

a fixed alkali; or that the nitrous acid, deprived by the quicklime of part of its phlogiſton, might be rendered more capable of contracting a ſtrong union with the quicklime. From what Mr. Pott has ſaid in his Diſſertation, the nitrous acid ſeems, by treatment with quicklime, to be rendered ſuſceptible of an entire decompoſition. *See his Diſſertation in the French edition of his works, by Mr.* MACHY, *tom.* III. *p.* 178.

A great quantity of nitre with earthy baſis is found ready formed in nitrous earths and ſtones. Nitre is moſt frequently produced in that form. This nitre may be decompoſed by a fixed alkali, which unites with its acid, and precipitates the earth, in the proceſs for making ſalt-petre. The mother-waters obtained in theſe operations contain ſtill a large quantity of this nitre with earthy baſis. *See the word* NITRE *in the preceding article.*

CCCCLXXVI. NITRE (CUBIC *or* QUADRANGULAR). When nitrous acid is ſaturated with mineral alkali, a neutral ſalt is formed, ſuſceptible of cryſtallization and of detonation, and conſequently is a kind of nitre. This ſalt has all the eſſential properties of nitre with baſis of fixed vegetable alkali; but the marine alkali, which is its baſis, changes the form of its cryſtals, which are not channelled priſms, like thoſe of ordinary nitre, but are cubes, or ſometimes parallelipipedons, with rhomboidal faces. From theſe forms the ſalt has been called *quadrangular nitre.*

We may make quadrangular nitre by combining directly the nitrous acid to the point of ſaturation with the cryſtals of ſoda, or by precipitating with this alkali the ſolutions of earths and metals made by nitrous acid, or by precipitating with common ſalt the metallic ſolutions in nitrous acid, which are ſuſceptible of this precipitation; or, laſtly, by decompoſing common ſalt by pure nitrous acid in the operation for making the diſtilled aqua regia. In all theſe caſes the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This ſalt is not uſed in medicine, chemiſtry, or the arts, as it is rather inferior than preferable to ordinary nitre.

CCCCLXXVII. NITRE FIXED *by* ARSENIC. This preparation is the alkali of nitre, the acid of which has been expelled in an open fire by means of arſenic, of which, therefore, ſome portion is retained by the alkali. To make this preparation, ſome nitre is to be put into a crucible, which is to be placed in a furnace. When the nitre is red, a ſmall ſpoonfull of white arſenic powdered is to be projected upon it, which cauſes a great effervеſcence, and afterwards vapors to aſcend; ſo that theſe phenomena are ſimilar to thoſe which happen when nitre is detonated. They are, however, different. In the detonation of nitre, the acid is burnt and deſtroyed; but in this operation the acid is only diſengaged from its baſis by means of the arſenic which has that property. The ebullition above-mentioned is cauſed by the powerful action of arſenic upon nitre. The fumes which riſe copiouſly in this operation are a mixture of thoſe of very concentrated nitrous acid with a part of the arſenic which is ſublimed by the heat.

Arſenic is thus projected at different times into the crucible, till no more effervеſcence is perceived, and then the operation is finiſhed. The fumes which riſe in this experiment muſt be very noxious, and therefore it ought always to be done under a chimney which draws well.

As arſenic cannot diſengage the nitrous acid but in proportion as it combines with the baſis of the nitre, we might expect to find in the crucible, after the operation, the alkali of the nitre perfectly ſaturated with arſenic. Nevertheleſs, the remaining matter is very alkaline, very far from the point of ſaturation, and retains but a little arſenic. The cauſe of this is, that the contact of the air and the vapor of the coals make moſt of the arſenic fly off as faſt as it combines with the alkali; for when the evaporation is made in cloſe veſſels, the alkali of the nitre is neutraliſed, and entirely ſaturated with arſenic. *See* Arsenic, *and* Salt (Neutral Arsenical).

Nitre fixed by arſenic cannot be employed but as an alkali which contains a certain quantity of arſenic, and mixed with a ſmall portion of nitre which may eſcape the action of the arſenic towards the end of the operation. This alkali may be employed as a flux, as it powerfully aſſiſts vitrification, as Mr. Pott has done in his experiments mentioned in the Lithogeognoſia.

CCCCLXXVIII. **NITRE FIXED *by* COALS.** To make nitre fixed or alkaliſed by coals, the proper quantity of nitre is to be put into a crucible, which ought to be ſo large that the nitre ſhall take up but a ſmall ſpace in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red-hot, a ſmall ſpoonfull (about a dram or half a dram) of charcoal groſly powdered is to be projected upon it. Inſtantly a vivid inflammation happens, which continues till all the charcoal is entirely conſumed. When this inflammation or detonation ceaſes, another quantity of charcoal like the former is projected upon it, and is left to be conſumed; and thus charcoal is continually to be projected till no more detonation is cauſed by it.

Then the matter contained in the crucible, which at firſt is very fluid, becomes afterwards thick and almoſt ſolid, becauſe it is then fixed alkali, which is much leſs fuſible than nitre. The fire muſt be encreaſed ſufficiently to make this alkali melt. During this fuſion, ſome ſmall detonations happen from time to time, which are occaſioned by a portion of nitre which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preſerved from the contact of the coals. When the matter is in good fuſion, and no detonation happens upon projecting ſmall bits of coals, we may then know that the nitre is alkaliſed, and that the operation is finiſhed. We ought to remark upon this ſubject, that when the ſmalleſt poſſible quantity of nitre undecompoſed is intended to be contained, more coal muſt be added than ſeems to be neceſſary for alkaliſing the quantity of nitre. In this caſe the alkali is generally phlogiſticated, unleſs it be afterwards calcined a very long time in an open fire.

If, on the contrary, it is intended to be as much dephlogiſticated as poſſible, and incapable of giving or retaining any extraneous taſte or ſmell; and if its perfect purity from undecompoſed nitre be not required; then in the preparation leſs charcoal ought to be uſed than is neceſſary for the detonation of the whole quantity of nitre. This remark is alſo applicable to nitre alkaliſed by tartar and by all other inflammable matters. *See* Alkali (Fixed Vegetable), *and* Detonation *of* Nitre.

CCCCLXXIX. NITRE FIXED *by* METALS. All the metallic ſubſtances which are ſuſceptible of decompoſition being treated in the fire with nitre, alkaliſe it, and make it detonate more or leſs ſenſibly. The moſt inflammable of theſe ſubſtances, as zinc and iron, make with this ſalt ſo luminous and ſo brilliant a detonation, that they are advantageouſly employed for that purpoſe in fire-works. Other combuſtible matters are leſs effectual, but their inflammation with nitre is ſufficiently ſtrong to produce all the eſſential effects of the detonation of nitre; ſo that after this inflammation, the acid of the ſalt is deſtroyed and burnt with the phlogiſton of theſe metals, and its alkali only remains mixed with the earth of the calcined metals. We may then ſay, that nitre is fixed by metals, as well as we ſay that it is fixed by coals or by tartar.

After the detonation of nitre with metals, its alkali may be eaſily obtained alone, and ſeparated from the metallic earths, by lixiviating with water the remainder. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry ſtate. It is eſſentially the ſame as nitre alkaliſed by any other inflammable matter, only that it is much more acrid and cauſtic, and reſembles thoſe alkalis which have been treated with quicklime.

In ſome known operations of chemiſtry we may obſerve this cauſticity which the alkali of nitre acquires after detonation with metallic matters. Such are the operations for diaphoretic antimony, and for the tincture of metals, or *lilly of Paracelſus*, in which the alkaliſed nitre is rendered exceedingly cauſtic by the metallic calxes. As, on the other ſide, volatile alkali treated with theſe metallic earths becomes always *fluor*, in the ſame manner as when treated with quicklime, we may conclude that metallic calxes act in general upon alkalis as quicklime does. *See the articles of the ſeveral metals, and of* ALKALI (FIXED), *and* DETONATION *of* NITRE.

CCCCLXXX. NITRE FIXED *by* TARTAR. This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only groſsly powdered. This mixture is to be put into an open veſſel of unvarniſhed earthen-ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at firſt weakly: but as the matter firſt inflamed kindles the reſt, the detonation encreaſes, a thick fume riſes, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the veſſel if this be not ſufficiently large: then the detonation gradually diminiſhes, and at laſt ceaſes. The reſiduum conſiſts of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, ſubject to contain a conſiderable quantity of nitre undecompoſed, and of inflammable matter not burnt, particularly when a ſmall quantity only is prepared at once: but it may be compleatly alkaliſed by a proper calcination, and by treating them like other fixed alkalis. *See* ALKALI (FIXED VEGETABLE).

Nitre fixed by tartar is alſo called *white flux*, becauſe the moſt frequent uſe of this alkali is to facilitate the fuſion of ores and metallic matters in eſſays and ſimilar operations, for which purpoſes it need not be perfectly pure. *See* FLUX (WHITE), *and* DETONATION *of* NITRE.

CCCCLXXXI. NITRES (METALLIC), *or* **NITRES** *with* **METALLIC BASES.** Thus may be named all neutral ſalts compoſed of the nitrous acid united with a metallic ſubſtance; and the ſeveral kinds of theſe nitres may be diſtinguiſhed by ſaying, nitre of ſilver, nitre of lead, of mercury, &c. *See* SALTS.

The nitrous acid acts in general powerfully upon all metallic ſubſtances, but with remarkable differences, depending on the peculiar natures of the metals.

Some metals, as gold and platina, cannot be diſſolved in their ſtate of aggregation by nitrous acid alone, and require the concurrence of marine acid. Others, as tin and regulus of antimony, are attacked ſo powerfully, and are ſo well dephlogiſticated by nitrous acid, that, as ſoon as they are diſſolved, they are reduced into a white calx, which ſeparates from the acid, and cannot remain united, becauſe they want phlogiſton. The marine acid combined with nitrous acid moderates much the action of the latter acid on theſe metals, prevents their calcination, preſerves a part of their phlogiſton, and thus is an intermediate ſubſtance by which they remain united with the nitrous acid.

Other metals, ſuch as copper and iron, are eaſily ſoluble by nitrous acid alone, and remain united when the acid is in much larger quantity than is neceſſary to diſſolve the metal: but when the acid is ſaturated, a part of theſe metals always precipitates in ſtate of calx, and the part which remains united with the acid forms an imperfect neutral ſalt, very deliqueſcent, and not, or very little cryſtallizable.

Laſtly, the other metals, particularly thoſe called *white* or *lunar*, ſuch as ſilver, lead, mercury, biſmuth, and even regulus of arſenic, are very ſoluble in nitrous acid, which they ſaturate, from which they do not precipitate without addition, but form with it compleat neutral ſalts ſuſceptible of cryſtallization.

Nitrous acid adheres ſo ſtrongly to theſe metals, that the metallic ſalts formed by them are ſuſceptible of detonation, but not ſufficiently to reſiſt the action of fire, which expels it without the help of any intermediate ſubſtance.

The nitre of ſilver is known by the name of lunar cryſtals. *See* CRYSTALS (LUNAR). Mercurial nitre is alſo frequently called *cryſtals of mercury*. This ſalt reſembles much the nitre of ſilver by its principal properties. *See* MERCURY. The nitre of lead has this peculiarity, that by expoſure to fire without addition of inflammable matter, it decrepitates ſtrongly, and even inflames and detonates. This phenomenon muſt be attributed to the phlogiſton of the lead which is the baſis of this ſalt. Much danger therefore attends the expoſure of nitre of lead to fire in cloſe veſſels. Probably the nitre of biſmuth, and that of regulus of arſenic, would exhibit the ſame phenomenon, as the phlogiſton of theſe two ſemimetals is as inflammable as that of lead.

CCCCLXXXII. NUTMEG. (*n*)

(*n*) Nutmegs. This fruit contains two kinds of oils, namely, a groſs ſebaceous oil, and a volatile eſſential fluid oil; in which laſt the peculiar taſte and ſmell of nutmegs reſide. The eſſential oil alſo appears to be of two kinds; one of which is ſo light, as to ſwim upon water, and to riſe in diſtillation with ſpirit of wine; and the other is ſo groſs and ponderous, that it ſinks in water, and is with difficulty capable of being diſtilled with water, and not at all with ſpirit of wine. Sixteen ounces of nutmegs yielded, by diſtillation, half an ounce of eſſential oil, and afterwards four or five ounces of the groſs ſebaceous oil were found floating on the ſurface of the water in the ſtill. Rectified ſpirit of wine diſſolves all the eſſential oil, and a part of the expreſſible oil. From four ounces of nutmegs nine drams of a concrete oil were expreſſed. This oil contains a conſiderable portion of the eſſential oil. It is brought from India, in form of cakes, and is called *oil of mace*, the mace being one of the exterior coverings of the nutmeg, and containing ſimilar oils. *Neuman.*

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CCCCLXXXIII. OCHRE. (*o*).

CCCCLXXXIV. OCULUS MUNDI. (*p*).

CCCCLXXXV. OFFA ALBA. (*q*).

CCCCLXXXVI. OIL. Oil may in general be defined a compound body, little, if at all, ſoluble in water, which is capable of burning with a flame accompanied with ſmoke and ſoot, and of leaving a reſiduum of coal after its diſtillation.

All oils are compoſed of phlogiſton, acid, water, and earth; for all theſe principles are diſcovered in the decompoſition of any oil, as we ſhall ſoon ſee.

(*o*) OCHRE. Ochres are ferruginous earths, or calxes of various colors, red, yellow, brown. They ſeem to have been depoſited from ferruginous or vitriolic waters, nearly in the ſame manner as a reddiſh or yellowiſh powder is precipitated from ſolutions of iron in vitriolic acid merely by expoſure to air. By reduction with charcoal or other inflammable matter a conſiderable quantity of iron may be extracted from theſe earths. Wallerius ſays, that the iron thus obtained from ochres is of the kind called *red-ſhort*, that is, brittle when hot. Ochres are uſed as pigments. By calcination, they all acquire a red color. *See* ORES *of* IRON.

(*p*) OCULUS MUNDI is a variety of the opal. *See* OPAL. It is opake, and its color is generally yellowiſh. It has this peculiar property, that by lying ſome hours in water, it becomes tranſparent, and of a yellow amber color. Some are ſaid to acquire by this means a luminous flame color.

(*q*) OFFA ALBA, *or* OFFA HELMONTII. When rectified ſpirit of wine is added to a ſolution of mild volatile alkali in water, the ſpirit having a ſtronger diſpoſition than the alkali to unite with the water, and having no diſpoſition to unite with the alkali, precipitates the alkali from the water. The alkali thus precipitated, being mild, or combined with fixable air, acquires a ſolid or concrete ſtate, and is not different from the common mild concrete volatile alkali. It is called the *offa alba*, or *offa Helmontii*. No ſuch precipitation is effected by adding rectified ſpirit of wine to the cauſtic volatile alkaline ſpirit made with quicklime, becauſe the diſpoſition which cauſtic volatile alkali has to unite with water is ſo much ſtronger than that of mild volatile alkali, that the former cannot be ever obtained in a concrete ſtate. *See* ALKALI (VOLATILE).

But perhaps the water and earth which are in oils are in them combined together, and exiſt in the ſtate of an acid.

From what we have ſaid concerning the nature of oil, this ſubſtance appears to conſiſt of ſeveral principles (*r*). It is alſo one of the proximate principles of all vegetables and animals. The oil in theſe ſubſtances even conſtitutes the eſſential diſtinction betwixt them and thoſe of the mineral kingdom, for in no mineral can the ſmalleſt particle of oil be ſhewn. *See* KINGDOMS.

All the oil obtained from vegetable and animal ſubſtances has a certain number of general properties which form its character as oil; but is alſo much diverſified by many peculiar properties, according to the particular kinds of vegetable and animal matters from which it is extracted. Hence, the ſeveral kinds of oils are diſtinguiſhable from each other. In the preſent article we ſhall only mention the moſt general properties of oil.

All oils in general are volatile, that is, they may by a certain heat be raiſed into vapors. The heat neceſſary to evaporate the leaſt volatile oils is not even very conſiderable. It is much leſs than a red heat; accordingly oil may be conſidered as a volatile body.

All oils which are expoſed to a heat capable of evaporating them, are eaſily inflammable, in open air, by contact of any inflamed matter, and burn with a white, luminous flame, accompanied with ſmoke. Oils, like all other combuſtible bodies, are entirely decompoſed by their inflammation. This inflammability of oil ſhews that phlogiſton is one of its principles.

The inflammable property of oil has miſled the ancient chemiſts down to the time of Beecher and Stahl. They gave the name of *oil* to the inflammable principle of metals, of ſulphur, and of charcoal, as well as to what is properly called oil. But the inflammable principle which enters into the compoſition of theſe bodies is only one of the conſtituent parts of oil; and oil cannot tranſfer this principle to any other body without being previouſly decompoſed, and ceaſing to be oil. *See* PHLOGISTON.

If any oil be diſtilled without an intermediate ſubſtance, at firſt a little acid phlegm ariſes, and afterwards the oil itſelf; and when a greater degree of heat than that of boiling water has been neceſſary to raiſe it, it always acquires an empyreumatic quality, ſo much ſtronger as the heat requiſite to be employed was greater. This oil is always accompanied with an acid, which becomes more and more ſtrong as the diſtillation advances. In the retort a ſmall quantity of fixed and reſiduous coal remains. This coal, and alſo the ſoot of oil, are very difficultly combuſtible; but at length their whole inflammable principle may be burnt: then nothing remains but aſhes, which, when well waſhed from any veſtige of fixed alkali which they may contain, are a pure earth.

If the oil in the receiver be examined, we ſhall find that it is leſs in quantity than the oil originally employed; from which we may know that a quantity of oil has been decompoſed by the operation. The water, acid, and earth evidently proceed from the decompoſed portion of oil. Hence all oil contains

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(*r*) Beſides the principles or conſtituent parts of oil, mentioned in the text, we may add, that oils when decompoſed by heat, or by mineral acids, emit a very large quantity of elaſtic vapor, or a kind of fixable air.

the principles mentioned in the definition. This is further aſcertained by rediſtilling the ſame oil, by which another portion of it is decompoſed, and the ſame principles are obtained. By repeating the operation a number of times, the whole oil may thus be decompoſed into water, acid, earth. The phlogiſton of the decompoſed oil is diſſipated in inſenſible vapors, which cannot be confined and collected, excepting that portion of it which remains fixed in the reſiduous coal.

An important remark may be made on theſe repeated diſtillations of oils, which is, that the undecompoſed portion of oil which paſſes over into the receiver, becomes by each diſtillation more and more thin and volatile. But as oils chiefly differ from each other in greater or leſs fluidity and volatility, by repeated diſtillations, therefore, theſe differences are leſſened, and all oils are approximated to a common ſtate.

Theſe experiments have not been proſecuted ſo far, as to enable us to determine the poſſibility of reducing all oils to one and the ſame ſtate; but every thing inclines us to believe that poſſibility: and in this caſe we muſt conclude, that oil in its greateſt purity and ſimplicity, and which might be called the *oily principle*, is eſſentially and identically the ſame in all vegetable and animal matters; and that the differences, although very numerous and conſiderable, betwixt the ſeveral kinds of oils, proceed only from the extraneous matters combined with them, by the mixture of which their eſſential properties are more or leſs altered, or diſguiſed.

We have further another very important conſideration upon this ſubject, to which we ought to attend, and which ſeems to counteract the opinion we have now explained. This is, that the greater thinneſs and volatility which oils have, either naturally, or by repeated diſtillations, the leſs ſoot they form when burnt, the leſs reſiduous coal they leave, and the ſtronger diſpoſition they acquire to mingle together, or to diſſolve in water; ſo that by continuing this attenuation of oils, they might probably be brought to the ſtate of ether, and perhaps to that of ardent ſpirits, which certainly is eſſentially different from that of oils. Hence we learn, that by repeated diſtillations, oils are not only purified and rendered ſimpler, but are alſo eſſentially altered and changed.

All oils are alſo capable of alteration by the action of air, and by the concurrence of other circumſtances which favor fermentation. The thinneſt and moſt volatile part of them is diſſipated; hence they become thick, and leſs volatile; and alſo the acid combined in oils thus expoſed is more and more unfolded, and diſengaged.

Acids have in general a power of acting upon oils. But the effects produced by their combination with them are very various, according to the nature of the acid, to its degree of concentration, and to the kind of oil.

Mineral acids, even the ſtrongeſt, act in general but very weakly or not ſenſibly upon oils, when they are diluted in a large quantity of water; becauſe this water with which they are more than ſaturated, and with which they have a ſtrong affinity, prevents their acting efficaciouſly upon the water and phlogiſton which are principles of the oil. But when they are concentrated ſufficiently, they unite then to the principles of the oil, with a force proportionable to the degree of concentration of the acid, and to the affinity which it has with the inflammable principle, and with water.

Concentrated vitriolic acid attacks powerfully all the principles of oil, occaſions an ebullition, conſiderable heat, and vapors, the ſmell of which is that of volatile ſulphureous acid mixed with empyreuma. By this mixture, the color of the oil is changed to a brown, red, or blackiſh, and its conſiſtence is rendered very thick.

The action of nitrous acid upon oils is ſtill more vivid, more quick, and remarkable than that of vitriolic acid. From this mixture a more conſiderable quantity of vapors riſe, the efferveſcence is much ſtronger, the thickening of the oil is ſooner effected, and the heat is ſo great with moſt oils, that when the nitrous acid is much concentrated, the mixture becomes red-hot, and is inſtantly inflamed. *See* INFLAMMATION *of* OILS.

The action of even the moſt concentrated marine acid is very different from that of the vitriolic and nitrous acids upon oils; it is much weaker, and we may even ſay that marine acid does not form any union with oils.

The difference of the effects of theſe three acids upon oils evidently proceeds from the difference of their affinities with the inflammable principle: for we may obſerve a ſimilar gradation in the action of theſe acids upon oils, and upon metallic ſubſtances.

As the ſeveral kinds of oils have their peculiar characters and properties, they alſo ſhow conſiderable diverſity in the phenomena exhibited by mixture with acids. We ſhall find ſome details on this ſubject under the ſeveral articles of the different kinds of oils. We ſhall only obſerve here, in general, that the vitriolic and nitrous acids are diſpoſed to unite very intimately with all oils that are very thin, volatile, and inflammable. But theſe qualities make them even elude the action of the acids when much concentrated; for during the reaction, they are almoſt entirely, and ſometimes inſtantly, diſſipated in vapors.

The oils which are leaſt thin and volatile, and which are diſpoſed to thicken ſpontaneouſly by the evaporation of their moſt ſubtle parts (which property they owe to a certain quantity of reſinous or gummy matter contained in them), are capable of ſuſtaining all the action of acids, and therefore are the fitteſt to be inflamed by mixture with concentrated nitrous acid.

Laſtly, all oils which have a certain degree of unctuoſity and conſiſtence, which are not volatile, nor diſpoſed to thicken by evaporation, reſiſt more the action of acids. They are not altered, nor are half decompoſed, like the preceding oils, by acids. They unite with them more ſlowly and difficultly, and can only be thickened by the united action of the vitriolic and nitrous acids. By being united with theſe acids, they receive the character of an acid ſoap, or greaſe, as we ſhall ſee in the article of theſe oils.

The acids alſo are altered by combination with oils. We may ſay in general that acids are rendered weaker and milder by union with oils, and that this union approximates them to the character of vegetable acids, or even entirely aſſimilates them to theſe acids: ſo that if it be true, as we have reaſon to believe, that vegetables and animals are formed from minerals differently modified, the differences betwixt mineral acids, and the acids of the vegetable and animal kingdoms, muſt be attributed to the oily principle which the latter acids poſſeſs excluſively.

This opinion would be completely proved, if we could ſufficiently ſimplify vegetable acids to reduce them to the quality of mineral acids, and particularly of the vitriolic, or to tranſmute perfectly a mineral acid into a vegetable acid. But theſe important reſearches have not yet been made, or imperfectly, and not ſo fully as they deſerve.

To tranſmute a mineral acid into a vegetable by uniting it with the oily principle, this union probably requires to be very intimate, without, however, altering in any meaſure the conſtituent parts of the oily matter. For if we employ the vitriolic or nitrous acid ſo much diluted that it ſhall not alter the oil with which it is to be united, many obſtacles will then occur to prevent its intimate combination, the removal of which obſtacles, however, we muſt acknowledge has not been ſufficiently attempted; and on the other ſide, if acids be employed, ſo concentrated that they can act eaſily and effectually upon oils, they will then ſenſibly alter and half decompoſe them.

If we try, for inſtance, to ſeparate by diſtillation the vitriolic acid from an oil with which it had been combined in its concentrated ſtate, we ſhall only obtain from thence a very watery and ſulphureous vitriolic acid; a certain quantity of empyreumatic and ſulphureous oil; a ſtronger vitriolic acid, but ſtill ſulphureous; a thick and bituminous empyreumatic oil; ſulphur which will be ſublimed to the neck of the retort; and laſtly, a fixed and reſiduous coal, more abundant than would have proceeded from the oil, if it had been diſtilled alone.

In this experiment we evidently ſee that a part of the oil is decompoſed, that the vitriolic acid is not otherwiſe changed than by becoming ſulphureous, and that it is conſequently not approximated to the nature of vegetable acids. *See* ACID SULPHUREOUS, *and* SULPHUR.

The great quantity of water mixed with the firſt portion of acid which riſes, is certainly a part of the watery principle of the oil, ſince the acid employed was concentrated. This acid becomes ſulphureous, and forms ſulphur, from the union it contracts with a part of the phlogiſton of the oil. Laſtly, the reſiduous coal is more conſiderable in this diſtillation, becauſe a larger quantity of earthy principle is ſeparated from the other conſtituent parts of the oil, and particularly from the watery part. The ſmall portion of the vegetable acid obtained in the diſtillation of oils without addition, does not appear in the preſent experiment, becauſe it is diſguiſed, or even decompoſed, by the vitriolic acid.

I do not know that mixtures of concentrated nitrous acid with oils have been diſtilled; but probably phenomena ſimilar to thoſe we have mentioned would happen, with thoſe differences only which would be occaſioned by the particular properties of that acid.

Of all the experiments hitherto made on the combinations of mineral acids with inflammable matters, thoſe concerning the mixtures of mineral acids with ſpirit of wine ſeem to promiſe moſt ſucceſs for the tranſmutation of theſe acids into vegetable acids; becauſe the mineral acids are very intimately united with the principles of the ſpirit of wine; becauſe theſe acids are neceſſarily diluted with the water which is a conſtituent part of the ſpirit of wine, and which is in much larger quantity than in oils; and laſtly, becauſe the action of acids upon ſpirit of wine is ſuch, that it entirely approximates that ſpirit to the nature of oil, altho' the inflammable principle of ſpirit of wine be not in an oily ſtate, and although all vegetable acids do manifeſtly contain an oil. Accordingly, if we would proſecute this aſſimilation of mineral acids to vegetable acids, the beſt method ſeems to be by treating them with ſpirit of wine. *See* SPIRIT *of* WINE, ETHER (VITRIOLIC, *and* NITROUS).

All oils diſſolve ſulphur, and form with it a compound, called *balſam of ſulphur.* The connexion of phlogiſton with vitriolic acid ſeems to be much weakened in the ſulphur by the intervention of oil; for if balſam of ſulphur be diſtilled, the ſulphur will be totally, or in great meaſure decompoſed, ſince only the ſame principles are obtained by this diſtillation as are obtained by diſtilling the combination of the oil with vitriolic acid. *See* BALSAM *of* SULPHUR *and* SULPHUR.

Alkalis act upon all oils, and combine with them to a certain degree, but more or leſs readily, according to the nature of the oil. In general, the leſs thin and volatile any oil is, the more eaſily ſoluble is it by alkalis; and reciprocally.

From the combination of an alkali with an oil reſults a compound more or leſs thick, called *ſoap*. The oil which enters into the compoſition of ſoap becomes eaſily miſcible with water by means of the alkali, but is not perfectly diſſolved in water; for the ſolution of ſoap has always a white milky appearance; which ſhews that the oil of ſoap diſſolved in water is in a ſtate ſimilar to that of an emulſion. This proves at the ſame time that the combination of oils with alkalis is not intimate; accordingly the oil receives no alteration, or ſcarcely any from the alkalis: for it may be ſeparated by means of any acid, and then it is found to be in the ſame ſtate it was in before its entry into the ſoap. *See* SOAP.

Oils may be united with metallic ſubſtances. They attack moſt ſenſibly copper and lead. Oils diſſolve copper even without heat, and from this ſolution reſults a blueiſh-green ſhining matter. The action of oils upon this and other metals is probably by means of their acid and phlogiſton. The concurrence of the air perhaps facilitates this ſolution; perhaps even it is neceſſary.

Oils are moſt eaſily combinable with the calxes of lead, as minium, ceruſs, and litharge, probably becauſe theſe preparations are much divided, and the oils which have the greateſt diſſolving power are thoſe which are the leaſt thin and leaſt volatile. When the calxes of lead are united only in ſmall quantity with oil, they do not deſtroy its fluidity, but diminiſh it, and give to the oil the property of drying much more readily.

Theſe oils, called *drying oils*, are much uſed in painting, from their drying quality. When a large quantity of calxes of lead is combined with oil, they form with it a ſolid, opake, and tenacious body, capable of ſoftening by heat. Theſe combinations are uſeful in pharmacy, for giving a convenient conſiſtence and tenacity to many plaſters. Mr. Geoffroy has obſerved, that calxes of lead combined with oils form compounds which have ſome ſaponaceous characters; that they communicate to water nearly the ſame taſte and unctuoſity that ſoap does, and make it lather in the ſame manner; that the oil may be ſeparated from the lead by means of acids, in the ſame manner as alkaline ſoaps may be decompoſed; and that the oil thus ſeparated is entirely ſimilar to that obtained by decompoſing ſoaps. Theſe combinations of oils with metallic ſubſtances have been examined but ſuperficially by chemiſts; nevertheleſs, they preſent very intereſting obſervations and particulars. We now proceed to the ſeveral kinds of oils.

CCCCLXXXVII. OILS (ANIMAL). All animal ſubſtances contain an oil, which is naturally unctuous, mild, and not volatile with the heat of boiling water. But, in general, the oil obtained from animals is in two very different ſtates, which ought to be diſtinguiſhed from each other.

The firſt ſtate is that of butter and fat. This kind of animal oil is thick or congealed, and owes this quality to a conſiderable quantity of acid intimately combined with it, and which cannot be unfolded but by the action of fire, or by the rancidity it contracts in time.

The oil of animals, which is in form of butter or fat, is not combined with the other principles of animal matters. It is diſtinct from them, is ſuperabundant to the animal compoſition, and is of a nature totally different from that which is combined with the animal ſubſtances. This ſuperabundant animal oil, which may be called *adipous oil*, reſembles perfectly wax, and thoſe vegetable oils called properly *fat oils*; and, like theſe, it contains no other ſaline ſubſtance than an acid. The acid of theſe oily matters is more intimately combined than in other kinds of oils. Hence they are much leſs apt to become rancid, furniſh leſs acid by repeated diſtillation, and are by this operation moſt difficultly rendered thin and volatile. *See* BUTTER, WAX, FAT, *and* OILS (FAT).

The oils of this kind which are contained in animals are fat, marrow, the expreſſed oil of yolks of eggs, ſpermaceti, and others of this nature.

The ſecond ſtate, in which the oil of animals is found, is in that of combination. The ſubſtance which forms almoſt entirely all the parts compoſing animal bodies, as fleſh, tendons, nerves, cartilages, bones, horns, hair, &c. is gelatinous, perfectly ſoluble in water, and which does not diſturb the tranſparency of water. This matter being diſtilled, furniſhes a large quantity of oil, which is one of the parts of the decompoſed ſubſtance. *See* JELLY. As this oil does not appear in the gelatinous matter before it has been decompoſed, and as this matter is perfectly ſoluble in water, we may infer that oil is one of the principles of jelly, and is rendered perfectly miſcible with water by means of the ſaline principles of that matter; it is conſequently in a ſtate perfectly ſaponaceous.

When the gelatinous matter has received no alteration, the oil which it contains appears abſolutely mild, and is not ſo volatile as to riſe with the heat of boiling-water; for freſh animal matters furniſh nothing by diſtillation with that heat but water, excepting thoſe which have peculiar ſmells, as muſk, caſtor, and others of that nature. But if a ſtronger heat be applied, they then furniſh much volatile alkali, and an oil; the firſt portions of which are thin, penetrating, and volatile. This is the oil which ought to be conſidered as the true animal oil. It has a ſmell ſtrongly empyreumatic, diſagreeable, and mixed with that of volatile alkali. This oil becomes more and more thick as it riſes in diſtillation, as is uſual in the diſtillation of all oils.

This animal oil differs eſſentially from fat, and from all vegetable oils. The cauſe of this difference ſeems to be, that the former oil does not appear to furniſh a ſingle particle of acid, but rather volatile alkali; whereas the latter oils contain an acid, which is unfolded and ſeparated by diſtillation.

CCCCLXXXVIII. OIL (ANIMAL) RECTIFIED, *or* OIL *of* DIPPEL. The animal oil deſcribed in the preceding article is ſuſceptible, as other oils are, of being attenuated, and rendered more volatile, by repeated diſtillations. By a ſufficient number of ſucceſſive diſtillations, it may be rendered almoſt as white, thin, and volatile as ether. It is diſcovered to acquire a property of acting upon the brain and nervous ſyſtem, and of allaying its irregular movements; which property is common to it with all other inflammable matters, when highly attenuated and very volatile. But this oil is particularly recommended for epileptic and convulſive affections. It is given from four to ten or twelve drops, incorporated with ſome proper vehicle.

The animal oil deſigned for medicinal uſes muſt have the above-mentioned thinneſs, as Dippel has obſerved, whoſe name it retains: but it is then very dear, from the long and troubleſome operations requiſite to give it that thinneſs, and from the ſmallneſs of the quantity obtained. Beſides, this oil, although perfectly well prepared, is very ſuſceptible of loſing its whiteneſs, and even its thinneſs, by a ſhort expoſure to air; which proceeds from the almoſt inſtantaneous evaporation of its more thin and volatile parts, and from the property which the leſs volatile remainder has of acquiring color. To avoid this inconvenience, it muſt be put, as ſoon as it is made, into very clean glaſs bottles, with glaſs ſtoppers, and expoſed as little as poſſible to the air.

Although all animal ſubſtances contain this oil, they are not all equally fit for furniſhing by diſtillation an oil capable of being rectified into a good oil of Dippel. For this purpoſe we ought to chooſe the parts of animals which contain the pureſt gelatinous ſubſtance, and which are entirely free from all fat; for the oil of fat, which neceſſarily mixes with the other oils in diſtillation, contains, as we have obſerved under the article OIL (ANIMAL), a large portion of acid intimately combined with it, from which it is very difficultly ſeparable, and therefore is not nearly ſo eaſily attenuated as the true animal oil; beſides that one of theſe oils has an acid, and the other an alkaline quality, and therefore their medicinal effects are probably different. Accordingly, as the fleſh, bones, blood of animals, contain always ſome oily ſubſtance of the nature of fat or marrow, they ought not to be choſen for the preparation of the oil of Dippel. Horns, and particularly thoſe of ſtags, which contain very pure gelatinous matter, are the animal ſubſtances from which the greateſt quantity of this oil can be obtained in good condition.

The moſt important obſervations concerning the method of making the oil of Dippel are: Firſt, to change the veſſels each diſtillation, or elſe to clean them perfectly; for a very ſmall quantity of the thicker and leſs volatile part is ſufficient to ſpoil a large quantity of that which is more rectified. In the ſecond place, Mr. Beaumé has obſerved, that this operation may be greatly abridged by taking care to receive none but the moſt volatile part in each diſtillation, and to leave a large reſiduum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four diſtillations a conſiderable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 diſtillations, without attending to this circumſtance.

CCCCLXXXIX. OILS (SWEET) *obtained from* VEGETABLES *by* EXPRESSION. Vegetable matters, at leaſt many of them, contain an oil in two different ſtates, as animal matters alſo do; that is, in vegetables a certain quantity of oil is ſuperabundant to their combination, does not enter into the compoſition of their proximate principles, is diſtinct, and is depoſited as a reſerve in different parts of plants; and alſo in vegetables another quantity of oil is combined, and is one of the conſtituent parts of their proximate principles. Such are the ſaponaceous extractive ſubſtance, acids, eſſential ſalts, mucilaginous matters. Of the former of theſe vegetable oils we treat in this article. This ſuperabundant and uncombined oil, which may be obtained from certain vegetables, may be diſtinguiſhed into two kinds; one of which is acrid, volatile, and odoriferous, and is called *eſſential oil*; the other kind is mild, is not volatile with the heat of boiling water, and has ſcarcely any ſmell. Of this latter we ſhall firſt treat.

Moſt grains and kernels are the particular reſervoirs of this ſuperabundant oil. If theſe ſubſtances be bruiſed and pounded, this oil appears, and exſudes from them. By triturating them with water, the oil is reduced into the ſtate of an emulſion; and by expreſſing them, a very large quantity of oil is forced out of them.

When the grains and kernels from which oil is thus extracted are recent and preſerved from rancidity, the oil obtained has a very mild taſte. It is at firſt a little turbid, by mixture of ſome of the other parts of the grain or kernel; but theſe matters afterwards ſeparate in form of ſediment, and the oil becomes clear.

Theſe oils are never very fluid and thin; on the contrary, they are conſiderably unctuous. They are not ſo volatile as to riſe in diſtillation with the heat of boiling water, as we have already ſaid; and when they are expoſed to a heat ſo ſtrong as to raiſe them into vapors, they then ſuffer a conſiderable alteration. Although they are mild and inodorous, yet by diſtillation they become very acrid and very empyreumatic. Although they are combuſtible, yet they cannot be inflamed merely by the touch of a kindled body, as all thoſe inflammable matters may, which, by their volatility, are continually evaporating. Expreſſed oils cannot be inflamed without a wick, or without a heat ſufficient to evaporate them.

Sweet expreſſed oils ſuffer by time ſeveral alterations; they loſe much of their mildneſs, contract an acrimony, and a ſtrong ſmell. Theſe changes, which are called *rancidity*, are occaſioned by a kind of internal fermentation, which produces effects ſimilar to thoſe of fire, but much more ſlowly and weakly. The acid which is intimately combined with theſe oils, and which does not ſhow itſelf when they are recent and have not been altered, diſengages itſelf more and more as they become old, in the ſame manner as it does by expoſure to fire. This is the reaſon why they become acrid in both caſes: for the ſame reaſon alſo, they acquire ſo much greater ſolubility in ſpirit of wine, (which they had not before) as they have become more rancid, or have been more frequently diſtilled. Mr. Macquer has ſhewn, in his Memoir concerning the Difference of Solubility of Oily Subſtances in Spirit of Wine, that this entirely depends on the ſtate of the acid of theſe ſubſtances; that they are ſo much more ſoluble as their acid is more copious and diſengaged; and reciprocally. We ſhall find ſome particulars upon this ſubject at the article ESSENTIAL OIL.

Of all oils, thoſe of which we now treat are the moſt proper for combining with fixed alkalis, and for forming good ſoap (*ſee* Soap); and alſo for diſſolving metallic matters.

All the ſweet ſuperabundant oils in vegetables, and which are capable of being extracted merely by expreſſion, reſemble each other by the general properties we have mentioned: but they differ conſiderably from each other by the degree in which they poſſeſs theſe and other properties. Some of theſe oils, as of linſeed, nuts, hempſeed, are diſpoſed to become rancid, to thicken, and to dry very quickly; they are capable of reſiſting a great degree of cold without being congealed; they form reſinous compounds when mixed with vitriolic and nitrous acids, and are eaſily inflamed by the ſmoking nitrous acid, as Mr. Rouelle has obſerved. Other oils, as thoſe of ben, olives, ſweet almonds, wallnut, &c. become much more ſlowly rancid and thick; they cannot be entirely dried; they congeal with a very ſlight degree of cold; they are leſs diſpoſed to combine with the vitriolic and nitrous acids; they form with theſe acids compounds, which rather reſemble fat or ſoap, as Mr. Beaumé remarks, than reſins; and, laſtly, cannot be inflamed, but by the concurrence of the vitriolic and nitrous acids highly concentrated. As theſe latter oils have, as to conſiſtence, a perfect reſemblance to *butter*, *fat*, and *wax* (*ſee theſe words*); and as they exhibit entirely the ſame phenomena, they juſtly deſerve to be diſtinguiſhed from all others by the particular denomination of *fat oils*.

In the claſs of theſe latter oils, we may range ſome concrete, oily, and mild matters obtained from vegetables; ſuch are the *butter of cacao*, the *green wax of Louiſiana*, and perhaps many others hitherto not ſufficiently examined. We may eaſily perceive, that among the great number of ſweet oils obtained by expreſſion, and which are not volatile. ſeveral of them muſt more or leſs partake of the nature of one or other of the two principal kinds we have juſt mentioned.

CCCCXC. OILS (ESSENTIAL). Thoſe oils are called *eſſential*, which have evidently the ſmell of the vegetable from which they are obtained. All theſe oils are ſufficiently volatile to riſe with the heat of boiling water: hence this degree of volatility is one of the ſpecific marks of theſe oils. They differ from all others, and particularly from thoſe mentioned in the preceding article, by this degree of volatility, which is peculiar to them.

We have reaſon to believe, that the greateſt part of the eſſential oil, which certain vegetables contain, is in a ſtate of combination, and makes part of ſome of their proximate principles. We are, however, certain, that many vegetables contain a ſuperabundant eſſential oil, uncombined, and depoſited as a reſerve in particular cells: ſuch is the oil which reſides in the rinds of oranges, lemons. citrons, in a word, of all fruits of that kind; which oil is ſo copious, that it may be obtained merely by expreſſion: ſuch probably are thoſe which are found moſt copiouſly and moſt manifeſtly in certain parts of plants; as the oil, for inſtance, which is found in the calix of roſes, but in too ſmall a quantity to be obtained by expreſſion alone.

However that be, as all eſſential oils are capable of riſing in diſtillation with the heat of boiling water; and as this degree of heat cannot occaſion any ſenſible alteration upon them (as may eaſily be ſeen by comparing the eſſential oil of citrons and others, obtained by expreſſion alone, with the oil of the vegetable extracted by a well managed diſtillation); by ſuch a diſtillation, therefore, may be obtained almoſt all the eſſential oils employed in chemiſtry and in the arts.

The moſt uſual and beſt method of obtaining the eſſential oil of a vegetable by diſtillation, is to take the plant in its prime of age, when its ſmell is the ſtrongeſt, and to chuſe thoſe parts of the plant in which the ſmell chiefly reſides; to put them in the cucurbit of an alembic without a water-bath; to add as much water as is ſufficient to prevent the plants from touching the bottom of the veſſel; to adjuſt a worm to the noſe of the alembic; and to give at once the degree of heat which is proper to make the water boil.

In this diſtillation, the water riſes impregnated with the ſmell of the plant, and it carries along with it all its eſſential oil. A part of this oil is ſo intimately mixed with the water which riſes in diſtillation, that it renders it turbid and milky; the reſt of the oil floats upon the ſurface of the water, or ſinks to the bottom, according to its ſpecific gravity. The diſtillation is thus to be continued, till we perceive that the water becomes clear; and more water muſt, from time to time, be put into the cucurbit, that the plant may be always kept moiſt with it. We ſhall ſee the reaſon of the ſeveral parts of this proceſs in the explanation of the particular properties of eſſential oils.

Not only theſe oils have all a ſtrong, aromatic ſmell, as we have already ſaid, but they have alſo a ſingular, and even an acrid and cauſtic taſte; in which reſpect they differ from the ſweet oils. This taſte proceeds from a copious and diſengaged acid, with which they are all penetrated.

The preſence of this diſengaged acid in eſſential oils appears from the impreſſion they make upon the corks of bottles, in which they are kept. Theſe corks are always ſtained of a yellow color, and a little corroded, nearly as they are by nitrous acid. Beſides, the vapor of theſe oils reddens blue paper; and the oils convert alkalis, with which they are triturated, into a neutral ſalt.

This acid is the cauſe of the ſolubility of eſſential oils in ſpirit of wine. They are not all equally ſoluble in this menſtruum, becauſe they do not all contain an equal quantity of acid. As this acid is almoſt diſengaged, and does not adhere ſtrongly in theſe oils, they loſe much of it by repeated diſtillations, and therefore their ſolubility in ſpirit of wine is leſſened by theſe operations; whereas ſweet oils, which, when recent, contain no diſengaged acid, and are therefore inſoluble in ſpirit of wine, become ſoluble in that menſtruum by diſtillation, which diſengages their latent acid, that was intimately combined with them; and this ſolubility may be encreaſed by repeating many times the diſtillation, as Mr. Macquer has proved in the Memoir quoted in the preceding article.

All eſſential oils are ſubject to loſe, by evaporation, their moſt volatile and thin part, in which the ſpecific ſmell of the vegetable, from which they are obtained, reſides; by which loſs they become thick, and acquire the conſiſtence and ſmell of turpentine, or even of reſins.

When in this ſtate, they are not, properly ſpeaking, eſſential oils, as they are no longer volatile with the heat of boiling water.

When eſſential oils, altered by time, but not yet entirely deprived of their peculiar ſmell, are diſtilled with the heat of boiling water, a part of them riſes in diſtillation, which has all the properties of eſſential oil freſhly diſtilled. As this portion of oil is renewed by this operation, it is frequently practiſed on eſſential oils, which begin to be altered by age; and this ſecond diſtillation is called the *rectification of eſſential oils.* We find in the cucurbit, after rectification, the reſinous portion of the oil, which is no longer capable of being raiſed by the heat of boiling water. This oily reſiduum may, however, be attenuated by diſtilling with a ſtronger heat, and even all the volatility and thinneſs of eſſential oils may be given to it, as alſo to all other oily matters, by diſtillations ſufficiently repeated. But ſuch oils have never the peculiar aromatic ſmell of the original eſſential oil.

From theſe properties of eſſential oil, we may conclude, that they receive their ſpecific character from their volatile odoriferous principle, that is, from the *ſpiritus rector* of the ſubſtance from which they were obtained; ſince they have the ſmell, thinneſs, and volatility which diſtinguiſh them, while they preſerve this principle, and loſe all theſe properties when it evaporates.

Theſe facts alſo ſhew the neceſſity of applying very quickly the degree of heat requiſite for the raiſing of theſe oils in diſtillation; for we may eaſily perceive, that as the ſpiritus rector is capable of riſing with a heat much leſs than that of boiling water, (which is neceſſary for raiſing eſſential oils) this ſpirit will riſe alone, when the heat is leſs than that of boiling water, and the quantity of eſſential oil obtained will be diminiſhed; ſo that if the diſtillation be continued with a leſs heat than that of boiling water, till the plant has loſt all the ſmell which it can loſe by this heat, no eſſential oil can then be obtained, or only a much leſs quantity of it.

As the ſpiritus rector is entirely ſoluble in water, therefore the water employed in this diſtillation of eſſential oils diſſolves a large portion of this ſpirit, and even becomes ſaturated with it. Accordingly, this water is much impregnated with the ſmell of the plant; but the oil by this means is in leſs quantity than it otherwiſe would be.

Hence we may infer, firſt, that no more water than is neceſſary ought to be employed; and, ſecondly, that the water which has thus riſen with the oil ought to be employed for other diſtillations preferably to pure water.

This water is not only much impregnated with the odoriferous principle of plants, but alſo it contains a conſiderable quantity of the thinneſt part of the eſſential oil, from which it receives a milky appearance. This portion of oil ſometimes remains a long time ſuſpended and half-diſſolved, by means of the ſpiritus rector: but, in time, a certain quantity of it is always ſeparated, which may be collected.

Eſſential oils are in general the moſt inflammable of all oils, becauſe they are the moſt volatile, and moſt eaſily reducible into vapors.

They unite more eaſily with acids than the ſweet oils which are not volatile.

With theſe acids they form reſinous compounds, or are inflamed, according to the nature and degree of concentration of the acid employed.

They are more difficultly combinable than the ſweet oils which are not volatile, with fixed alkalis, with which they form a particular kind of ſoap. *See* SOAP *of* STARKEY.

Some conſiderable differences may be obſerved betwixt the ſeveral eſſential oils. Although, in general, they are all capable of riſing with the heat of boiling water, ſome of them, however, may be obtained in a larger quantity by a heat ſomewhat ſtronger; and this is effected by mixing with the water ſalts (as common ſalt) which are incapable of acting upon oils, and by means of which the water is capable of receiving a ſtronger heat.

The ſpecific gravity of moſt of theſe oils is leſs than that of water, and accordingly they float upon the ſurface of this liquid. Some of theſe oils, however, are ſo heavy as to ſink in water; of this kind are the eſſential oils obtained from the aromatic vegetables of hot countries, as cloves, cinnamon, ſaſſafras, &c. To the diſtillation of theſe heavy oils a ſtronger heat is chiefly uſeful. Dry, woody, and compact matters, previouſly to the diſtillation of their eſſential oils, require the aſſiſtance of diviſion and maceration during ſome days.

The conſiſtence of eſſential oils varies much; ſome of them, as thoſe of turpentine, ſaſſafras, and citron, being very thin; and others, like thoſe of aniſeed and roſes, have naturally much conſiſtence, and are even congealed, unleſs they ſuſtain a certain degree of heat.

Although the weight and conſiſtence of eſſential oils proceed probably from the ſtate of their acid, as well as all the other differences betwixt them, yet theſe two properties ſeem to be independent of each other; for ſome oils are, at the ſame time, very thin and very heavy, while others are very light and thick. The oil of ſaſſafras, which is very fluid, is heavier than water; on the contrary, the oil of aniſeed, the conſiſtence of which is ſometimes equal to that of congelation, floats upon water.

The quantity of eſſential oil obtained from different vegetables is very various. Some vegetable ſubſtances, as ſavin, turpentine, and moſt balſamic and reſinous trees, furniſh a large quantity of oil. From others, as roſes, for inſtance, ſcarcely a ſenſible quantity of it is obtainable; and, laſtly, others, although they contain much ſpiritus rector, and have much ſmell, furniſh no eſſential oil by diſtillation: of this number are lillies, tuberoſes, and jaſmine.

Eſſential oils are employed in painting, in ſpirituous liquors uſed at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, ſmall doſes only are given internally, as from one drop to four or five, incorporated with ſugar, ſo as to form an oleoſacharum, or with other drugs in form of pills.

Theſe oils being inflammable, thin, and volatile, have in general a property of acting upon the nervous ſyſtem, and of allaying its irregular movements: it is therefore given as a cephalic, and antiſpaſmodic, in convulſive and hyſterical affections; they are alſo ſtimulant, ſudorific, and ſtrengthening. All drugs which are alexipharmac, cephalic, tonic, and ſtomachic, which contain vegetable aromatics, derive their virtues from the eſſential oils of theſe vegetables. The ſame may be ſaid of all medicinal, aromatic, and ſpirituous waters.

In ſome caſes, eſſential oils are employed externally as ſtrengtheners, and to allay painful ſpaſms of nervous and tendinous parts, to reſolve and diſſipate acrid humors, which occaſion pain without any ſenſible ſign of inflammation. When eſſential oils are applied externally in theſe caſes, they are ſo cauſtic that they muſt not be applied alone, as they would excite pain, redneſs, frequently inflammation, eryſipelatous eruptions, and excoriations. They are a kind of veſicatory. The beſt method of avoiding theſe inconveniences is, by mixing them with a ſufficient quantity of fat, or of fat oil, to form liniments or pomatums, with which the diſeaſed parts may be rubbed.

The eſſential oils, which are obtained from ſcarce and valuable ſubſtances, muſt alſo be very dear, and are therefore ſubject to much adulteration. Moſt of the books of chemiſtry explain the manner of making, or of diſcovering theſe adulterations. We ſhall only, in a ſummary manner, mention what is moſt important to be known on this ſubject.

Eſſential oils may be adulterated with any ſlavorleſs fat oil, with ſpirit of wine, or with any common and cheap eſſential oil. They who know the properties of theſe ſubſtances may eaſily diſcover the fraud. As fat oils are neither volatile nor drying, if a drop of the eſſential oil, to be examined, be put upon paper, it may be evaporated with a gentle heat; and when it is unmixed with fat oil, it will leave no greaſineſs nor tranſparency in the paper. This mixture may alſo be diſcovered by mixing a drop of the eſſential oil with ſpirit of wine, by which it will be entirely diſſolved if it be pure from fat oil; but if it has been adulterated with this latter kind of oil, this will remain undiſſolved in ſpirit of wine.

The mixture of ſpirit of wine with an eſſential oil may be diſcovered by addition of water, which immediately acquires a milky appearance; becauſe the ſpirit of wine quits the oil to unite with the water, and leaves the oil much divided and ſuſpended, but not diſſolved. This does not happen when the eſſential oil has not been adulterated with ſpirit of wine. Pure eſſential oil may, indeed, by agitation with water, be divided into ſmall globules, and may give a whiteneſs to the water: but theſe globules quickly unite again on the ſurface, or at the bottom of the water, according to their ſpecific gravity.

Laſtly, adulteration by another eſſential oil is moſt difficultly diſcoverable; becauſe the principal properties of theſe oils are common to all. Nevertheleſs, as eſſential oils are commonly adulterated with oil of turpentine, this fraud may be diſcovered by ſoaking a bit of paper or linen with the oil to be examined, and by quickly evaporating the oil, which will leave upon the linen or paper a ſtrong ſmell of turpentine.

CCCCXCI. OILS (FETID, EMPYREUMATIC). Under this name we comprehend all the oils of vegetable and animal matters obtained by diſtillation with a heat ſuperior to that of boiling water; becauſe theſe oils have a diſagreeable, burnt, or empyreumatic ſmell.

From this definition we ſee, that empyreumatic oils are not a diſtinct claſs; that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is expoſed to a degree of heat ſuperior to that of boiling water, all the oils which they contain, of whatever kind they may be, paſs in diſtillation; but are altered, by the fire, in their color, ſmell, and in many other of their peculiar properties. Beſides, if the matter thus diſtilled contains ſeveral kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be diſtilled, which contains an oil that is ſweet and not volatile, and alſo an oil in a reſinous ſtate, the fetid empyreumatic oil obtained will be only a mixture of theſe two oils half-burnt. The ſame may be ſaid of animal matters with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be eſtabliſhed as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are compoſed. Hence, if we would know the properties of any empyreumatic oil, we muſt previouſly know the kinds and proportion of oils contained in the ſubſtance from which it has been obtained, and alſo the changes ſuffered by each of theſe oils by the degree of heat requiſite to render them empyreumatic. We ſhall here only obſerve, that all empyreumatic oils are acrid, and more or leſs ſoluble in ſpirit of wine; that the portion of theſe oils which riſes firſt in diſtillation is always the thinneſt; that by repeated diſtillations they may be rendered more and more thin and volatile; and that by a ſufficient repetition of theſe rectifications, we may almoſt entirely deprive them of their empyreumatic ſmell, ſo that only a pungent and penetrating ſmell ſhall remain; which ſeems to be common to all oils treated in this manner.

CCCCXCII. OILS, *improperly ſo called.* Many preparations were by the ancient chemiſts called *oils*, merely from their conſiſtence, although in other reſpects they were entirely different from oil. Theſe improper names ought to be aboliſhed, and they are accordingly falling into diſuſe by modern chemiſts. Nevertheleſs, as they are found in moſt chemical books in the time of Lemeri, and as many of them are ſtill frequently employed, we ſhall explain in a few words the chief of them.

CCCCXCIII. OIL *of* ANTIMONY. By this name the butter of antimony, and ſome other ſolutions of antimony by acids, are called. *See* Butter *of* Antimony.

CCCCXCIV. OIL *of* ARSENIC. This is a combination of concentrated marine acid with arſenic, and is made preciſely in the ſame manner as butter of antimony. Equal parts of arſenic and of corroſive ſublimate are mixed and diſtilled together, by which a liquor is diſtilled, ſimilar to the butter of antimony. This is a very powerful, but, at the ſame time, very dangerous cauſtic. This ſhews, that arſenic, like regulus of antimony and ſeveral other metallic ſubſtances, is capable of decompoſing corroſive ſublimate by ſeizing its acid. Accordingly, mercury is revived in this as in all the ſimilar operations.

CCCCXCV. OIL *of* MERCURY. When water is added to a ſolution of mercury in vitriolic acid to form the precipitate called *turbith mineral*, the acid thus diluted ſtill retains a portion of mercury diſſolved, which is properly a vitriol of mercury. This ſalt, which is cryſtallizable, may be obtained by evaporating the water which keeps it diſſolved. When expoſed to a moiſt air, it deliquiates into a liquor which Lemeri calls *oil of mercury*. *See* Turbith Mineral.

Lemeri alſo gives the name of *oil of mercury* to a ſolution of corroſive ſublimate in ſpirit of wine.

CCCCXCVI. OIL *of* LEAD. This is a ſolution of ſalt of lead in the eſſential oil of turpentine. This ſalt is to be put into a matraſs, and upon it oil of turpentine is to be poured, till it covers the ſalt with a thickneſs of ſome fingers, and the whole is to be digeſted during ten or twelve hours. The liquor, ſays Lemeri, acquires a red color. That author directs that the ſolution ſhould be concentrated, by diſtilling from it a part of the oil of turpentine, and he recommends it for its utility in cleanſing and cicatriſing ulcers, particularly thoſe which are putrid. This preparation, which is certainly a powerful antiſeptic, muſt be very proper for theſe purpoſes.

Amongſt the oils improperly ſo called, this is one of thoſe to which the name of oil has been with leaſt impropriety given; for the baſis of it is actually oil, and that oil really keeps the lead in ſolution. Lemeri affirms, that we may thus entirely diſſolve a given quantity of ſalt of lead, by employing a ſufficient quantity of oil of turpentine. This preparation, which has only been made for medicinal purpoſes, is intereſting alſo in chemiſtry, and deſerves a particular examination.

CCCCXCVII. OIL *of* SULPHUR. Some chemiſts have given this name to the concentrated acid of ſulphur. *See* Sulphur.

CCCCXCVIII. OIL *of* TARTAR *by* DELIQUIUM. This name very frequently is given to fixed alkaline ſalt reſolved into a liquor by the moiſture of the air, or even to a ſolution of that ſalt in water. This name is unſuitable, not only as this liquor is not of the nature of oil, but alſo becauſe a true oil of tartar is obtained by diſtillation of tartar. This liquor ought to be called *alkali of tartar*, or *liquid vegetable alkali*. *See* Alkali (Fixed Vegetable), *and* Tartar.

CCCCXCIX. OIL *of* VENUS. Lemeri gives this name to the ſalt formed by the union of copper with the nitrous acid, when it is reſolved into a liquor by the moiſture of the air. It is a cauſtic and eſcharotic, like all other ſimilar combinations of metallic matters with any acids to which the name of oil was formerly given. An empyrical phyſician has rendered this name of oil of Venus famous in theſe latter times, by having applied it to a ratafiat of his compoſition, which has been found agreeable, and has been much in vogue.

D. OIL *of* VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. *See* Acid (Vitriolic), *and* Vitriol.

DI. OLEOSACHARUM. This name is given to a mixture of oil and ſugar incorporated with each other, to render the oil more eaſily diffuſible in watery liquors. Sugar and all ſaccharine matters have in general a quality ſomewhat ſaponaceous, and conſequently are capable of producing this effect in ſome meaſure. Theſe oleoſacharums are uſed in pharmacy as a method of adminiſtering eſſential and other oils. *See* Oils *and* Juices (Saccharine).

DII. OLIBANUM. (*s*)

DIII. ONIONS. (*t*)

DIV. OPAL. (*u*)

(*s*) Olibanum, *thus*, *frankincenſe*, is a gum-reſin, of an ounce of which water is capable of diſſolving three drams and a ſcruple, and ſpirit of wine is capable of diſſolving five drams and two ſcruples. *Neuman.*

(*t*) Onions. This root has an eſſential oil, which impregnates water in diſtillation with a very ſtrong ſmell, and which is ſo miſcible with the diſtilled water, that it cannot be collected ſeparately. The oil may alſo be combined with ſpirit of wine by diſtillation. From an ounce of the dry root ſix drams of extract may be obtained by ſpirit of wine, and ſomewhat more may be obtained by water. *Neuman.*

(*u*) Opal is an almoſt pellucid agate, the color of which varies by reflexion and refraction. Opals are milk-colored, blackiſh, yellowiſh, or greeniſh; which latter variety

DV. ONYX. (x)

DVI. OPIUM. (y)

DVII. OPOPONAX. (z)

DVIII. ORANGE. (a)

DIX. ORES. Ores are natural compounds, containing metals allayed with different ſubſtances.

Excepting gold, and a very ſmall quantity of each of the other metals found in ſome places ſo pure as to poſſeſs all their characteriſtic properties, nature exhibits to us metals and ſemimetals differently allayed not only with each other, but alſo with ſeveral heterogeneous ſubſtances, which ſo alter and diſguiſe their qualities, that in this ſtate they cannot ſerve for any of the purpoſes for which they are proper when they are ſufficiently pure.

The ſubſtances found naturally combined with metals, in the earth, are, particularly, ſulphur and arſenic, ſometimes ſeparately, but generally conjointly.

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is called *cats eye*. Opals are claſſed among the ſiliceous order of earths, although ſome of them are ſo ſoft as to be capable of being ſcratched with a knife. The *oculus mundi* is a rare but curious variety of the opal. It is opake, and generally of a yellowiſh color; but by being immerſed during ſome hours in water, becomes tranſparent, and acquires a bright yellow, or even a luminous flame-color.

(x) ONYX is an agate, generally opake, or but ſlightly tranſparent, conſiſting of differently colored veins, parallel to each other, ſometimes in ſtraight and ſometimes in curve lines. *See* AGATE.

(y) OPIUM is almoſt totally ſoluble in water or in ſpirit of wine. It contains a reſin, a gum, a minute portion of ſaline acidulous matter, water, and earth. On what its peculiar properties depend we do not well know. When opium is diſſolved in water, a fat, frothy, reſinous ſubſtance riſes to the ſurface, which is ſo ſtrong and active, that a few grains of it are ſufficient to kill a dog who could bear a whole dram of opium. From a pound of opium two or three drams only of this ſubſtance may be collected; but the opium contains more of it, which remains combined with the reſt of the juice. The narcotic matter of the opium appears to be diffuſed through all its ſubſtance, but more eſpecially to reſide in the fine volatile parts; which parts are capable of being highly concentrated by art. Neuman (from whom the above is extracted) ſays, that he knows a preparation of opium by which a whole chamber full of men may be preſently ſtupefied, deprived of their ſenſes, and even of their lives, without ſwallowing a ſingle grain. He thinks that it operates nearly in the ſame manner as the vapor of burning charcoal, or as the exhalations of fermenting liquors. The ſame author propoſes to render opium more mild and innocent, by diſſolving it in water and fermenting the ſolution. Dr. Lewis obſerves, that diminiſhing the doſe of opium is a more certain method of diminiſhing its effects. He alſo ſays, that alkaline ſalts diminiſh the ſoporific power of opium, and that acids almoſt totally deſtroy it.

(z) OPOPONAX is a gum-reſin, of an ounce of which two drams and two ſcruples are ſoluble by ſpirit of wine, and three drams two ſcruples are ſoluble by water. Both water and ſpirit, by diſtillation with opoponax, acquire its flavor; but no oil is thereby ſeparated. *Neuman.*

(a) ORANGE. The flowers of orange trees afford, by diſtillation, a very fragrant eſſential oil. From the rind of the fruit an eſſential oil may be obtained by expreſſion. The juice of the fruit contains an eſſential acid ſalt, mixed with much mucilage. This ſalt may be obtained in cryſtals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a ſaline extract may be made, capable of being preſerved, and poſſeſſed of the ſame medicinal qualities as the juice, which is ſaid to be very powerful in the ſcurvy.

Metals combined with theſe ſubſtances are called *metals mineraliſed by ſulphur*, or *by arſenic*, or *by ſulphur and arſenic*; and theſe matters are called *mineraliſing* ſubſtances.

Beſides the ſulphur and arſenic with which metals are ſtrictly combined in the mineral ſtate, they are alſo pretty intimately combined with earthy ſubſtances, of different natures, and more or leſs divided. A part of this earth is diſpoſed to metalliſation, and is convertible into a metal by combination with phlogiſton. It is called *metallic earth*, and probably proceeds from a portion of metal which has been decompoſed, and deſtroyed in its ore by different cauſes, which we ſhall mention afterwards. Perhaps alſo this earth may be only a ſimple earth naturally diſpoſed to metalliſation, or the firſt beginning of a metal which nature has not yet brought completely to a metallic ſtate.

We are to obſerve upon the ſubject of this metallic earth, that it is found not only amongſt mineraliſed metals, but that it appears diffuſed, although in very ſmall quantity, in large maſſes of ordinary earth which is found every where, ſuch as ſands, clays, and mud. Mr. Cramer thinks that the experiments mentioned by Beccher in his third Supplement to his *Phyſica Subterranea*, by which he extracts gold or iron from any ſands or clays, are demonſtrative upon this ſubject. The other portion of earth which is intimately mixed with mineraliſed metals, cannot be reduced into metals, and is therefore called *unmetallic earth*. This is an ordinary earth.

Theſe different matters united together form maſſes which are compact, heavy, brittle, and frequently poſſeſſed of much metallic luſtre. Theſe ſubſtances are properly called *ores*, or the matter of mines.

Theſe ores are found in earths and ſtones of different kinds, as ſands, flints, cryſtals, ſlates, indurated clays, according to the ground in which they are contained. But two kinds of ſtones in particular ſeem to accompany ores, and have therefore been conſidered by ſeveral mineralogiſts as matrixes, in which metals are formed. One of theſe ſtones is a kind of cryſtal, generally white, milky, and ſemi-opake, ſtriking fire with ſteel, and of the claſs of vitrifiable earths. It is called *quartz*. *See* QUARTZ.

The other ſtone is leſs hard, which does not ſtrike fire with ſteel, and is ſometimes milky like quartz; ſometimes tranſparent and diverſely colored, conſiſting of rhomboidal cryſtals, which are compoſed of plates and faces. This ſtone becomes more ſoft and friable by being expoſed to fire. It is called *ſpar*. Spar is more like to gypſeous ſtones than to any other, but it differs from gypſeous ſtones in poſſeſſing a much greater denſity. Some ſpars are ſo heavy, that they exceed in this reſpect all other ſtones. *See* SPAR.

Theſe earthy and ſtoney ſubſtances ought to be well diſtinguiſhed from the earth intimately mixed with the ore, as is mentioned above; this latter earth conſtituting part of the ore, whereas the others are only accidental, and externally adherent. They form the *matrix of the ore*.

Mines have generally the form of veins, or of congealed currents, which have different directions, and which are diſtributed in branches. The mines take different appellations according to the direction of their veins.

The *deep mines* are thoſe which deſcend from the ſurface of the earth, either vertically, or more or leſs obliquely towards its center.

Thoſe which are extended horizontally are called *dilated mines*, becauſe they frequently are conſiderably broad.

Some mines compoſe maſſes more or leſs extenſive, and almoſt equally long, broad, and thick. Theſe latter are called *accumulated mines*.

Some authors have ſaid that the veins of mines are always directed from eaſt to weſt, from north to ſouth, or in the intermediate directions, according to the nature of the metals. But this opinion is not well ſupported by facts; for we are certain that veins of every metal run in every direction. The direction of mines is determined by their deſcent, like that of rivers, and by help of a mariner's compaſs.

From ſeveral ſigns we may know that a field or a mountain contains a mine, particularly when the mine is near the ſurface of the earth. For, from grounds filled with minerals, ſulphureous and metallic vapors riſe, which are ſometimes ſo conſiderable as to affect the ſenſes, but which moſt frequently only ſhew themſelves by the effects which they produce on plants, which they render weakly, and diſcolored. Frequently even, mineralogiſts ſay, theſe places are entirely barren, and no vegetables grow there, although the ground ſeems to be of a good quality, and fit for vegetation.

The ſources of mineral waters; the nature of the ſtones upon the ground being that of quartz or ſpar; bits of minerals lying on the ground; are ſo many proofs of the preſence of mines.

But we muſt not altogether depend on theſe ſigns; for notwithſtanding them, we often find no mines, or very poor ones, when we dig the ground.

The digging of the ground is then the only certain method of determining the exiſtence of a mine, and of what kind it is; for the *wand of divination*, by which many pretend that mines and their quality may be diſcovered, is a chimera, which owes its reputation to credulity and ignorance.

Metallic minerals are divided into two claſſes. The firſt includes all thoſe, in which the quantity of metal exceeds the quantity of ſulphur, arſenic, and unmetallic earth; or from which metal may be advantageouſly extracted. Theſe minerals are particularly called *ores*.

In the ſecond claſs are placed all minerals which contain more ſulphur, arſenic, and unmetallic earth than metal; and theſe in general are called *pyrites*.

Pyrites and ores are of the ſame nature, and are often both found in the ſame places. But as the proportion of the principles of theſe compounds is different, their properties alſo differ. We ſhall explain the properties of pyrites under the article *pyrites*, and the properties of ores in this preſent article.

Ores may be conſidered in two ways; firſt, as containing uſeful and valuable ſubſtances, and they then receive their name from the moſt valuable metal which is obtained from them. Thus, for inſtance, as ſilver is much more valuable than lead, a mineral, a quintal of which contains a mark of ſilver, and ſixty pounds of lead, or more, is called *an ore of ſilver*, becauſe the mark of ſilver is more valuable than the 60 pounds of lead. This manner of denominating ores is chiefly uſed by the miners.

In the ſecond place, we may chiefly attend to the metal the largeſt quantity of which is contained in a mineral, without attending to its value, and affix its name to the ore. In this manner, the ore juſt now mentioned would be called *an ore of lead,* and not *an ore of ſilver*. But the beſt method ſeems to be, to call ſuch an ore *an ore of lead containing ſilver,* as is very frequently done.

Mr. Cramer, a profound and judicious chemiſt, who has particularly attended to this ſubject, thinks that we ought to call an ore, the *proper ore of that metal* which it contains in largeſt quantity, and to call it the *improper ore* of all the other metals it may contain. This method of diſtinguiſhing ores is certainly one of the beſt and moſt exact. We ſhall now give a ſummary deſcription of the principal kinds of ores of each metallic ſubſtance. (*b*).

(*b*) As metallurgy is the moſt important part of chemiſtry, we hope that a *ſketch of the Hiſtory of Mines*, and a more particular *enumeration of ores* than is contained in the text, together with a relation of the moſt approved methods of extracting metals from ores, for the purpoſes of *eſſay*, or of *commerce* and *manufacture*, may be not unacceptable. In the preſent Note, we ſhall treat of mines, and of ores in general: Under the articles in the text, which treat of the ores of the ſeveral metals, we ſhall ſubjoin an enumeration of thoſe which are there omitted, and alſo the methods of eſſaying the ſeveral ores to diſcover the quantities and qualities of their contents: Laſtly, under the article, SMELTING *of* ORES, we ſhall make ſome additions concerning the methods of extracting metals from large quantities of ores for the purpoſes of commerce and manufacture.

Concerning ORES *and* MINES.

ORES conſiſt, 1. Of metallic ſubſtances *calcined*; or, 2. Of theſe ſubſtances combined with other matters, with which they are ſaid to be *mineraliſed*.

Calcined metallic ſubſtances, or *calciform ores*, are metallic ſubſtances deprived of phlogiſton, and in the ſtate of a calx, or metallic earth. *See* CALX. Such are all *ferrugineus ochres*, which are calxes of iron.

Mineraliſed ores are, 1. *Simple*, containing only one metallic ſubſtance: or, 2. *Compound*, containing two or more metallic ſubſtances.

Of the ſimple, and alſo of the compound ores, four kinds may be diſtinguiſhed.

1. Ores conſiſting of metallic ſubſtances mineraliſed by *ſulphur*. Such is the lead-ore called *galena*, compoſed of lead and ſulphur.

2. Ores conſiſting of metallic ſubſtances mineraliſed by *arſenic*. Such is the *white pyrites*, containing iron and arſenic.

3. Ores conſiſting of metallic ſubſtances mineraliſed *by ſulphur and by arſenic*. Such is the *red ſilver-ore*, containing ſilver, arſenic, and ſulphur.

4. Ores conſiſting of metallic ſubſtances mineraliſed by *ſaline matters*. Such are the *native vitriols*. Such alſo is probably the *corneous ſilver-ore*, which, according to Mr. Cronſtedt's opinion, is a luna cornea, or ſilver combined with marine acid. Of this kind of ores, or native metallic ſalts, is perhaps the *ſedative ſalt of borax*, which appears, from Mr. Cadet's experiments, publiſhed in the Memoirs of the Royal Academy for the year 1766, to be copper combined with marine acid, and which has been ſaid to be found native. To this claſs alſo may be referred the *ſilver mineraliſed by an alkaline ſubſtance*, which Mr. Von Juſti pretends to have diſcovered.

Henckel, and after him Cramer, and the author of the Dictionary of Chemiſtry, pretend that in mineraliſed ores, beſides the above-mentioned metallic and mineraliſing ſubſtances, are alſo contained a metallic and an unmetallic earth. But Wallerius affirms, that the exiſtence of ſuch earths cannot be ſhewn, and that ſulphur is incapable of diſſolving unmetallic earths, and even the calxes of all metallic ſubſtances, excepting thoſe of lead, biſmuth, and nickel.

Having thus defined and diſtinguiſhed the ſeveral general claſſes of ores, we proceed to ſhew how they are lodged, and where they are found.

Metals and *metalliferous ores are found* in various places. I. They are found *under water*; in beds of rivers, lakes and ſeas, and chiefly at the flexures of theſe: Such are

DX. **ORES *of* GOLD.** In taking the word *ore* in the ſenſe above-mentioned, no ores of gold exiſt: for as this metal cannot be allayed

the auriferous and ferruginous ſands, grains of native gold, ochres, and fragments of ores waſhed from mines.

II. They are found *diſſolved in water*: Such are the vitriolic waters containing iron, copper, or zinc.

III. They are found *upon the ſurface of the earth*. Such are many ochres; metalliferous ſtones, ſands, and clays; and lumps of ores. Mr. Gmelin ſays, that in the northern parts of Aſia, ores are almoſt always found upon or near the ſurface of the ground.

IV. They are found *under the ſurface of the earth*. When the quantity of theſe collected in one place is conſiderable, it is called a *mine*.

Subterranean metals and ores are differently diſpoſed in different places.

1. Some are *infixed in ſtones and earths*, forming *nodules* or *ſpots* diverſely colored.

2. Some are equably and *uniformly diffuſed through the ſubſtance of earths and ſtones*, to which they give color, denſity, and other properties. Such are the greateſt part of thoſe earths, ſtones, ſands, clays, cryſtals, flints, gems, and fluors, which are colored.

3. Some form *ſtrata* in mountains. Such are the ſlates containing pyrites, copper-ore, lead-ore, ſilver-ore, or blend. Theſe lie in the ſame direction as the ſtrata of ſtones betwixt which they are placed, but they differ from the ordinary ſtrata in this circumſtance, that the thickneſs of different parts of the ſame metalliferous ſtratum is often very various; whereas the thickneſs of the ſtoney ſtrata is known to be generally very uniform.

4. *Fragments of ores* are frequently found accumulated in certain ſubterranean cavities, in fiſſures of mountains, or interpoſed betwixt the ſtrata of the earth. Theſe are looſe, unconnected, frequently involved in clay, and not accreted to the contiguous rocks or ſtrata immediately, nor by intervention of ſpar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here deſcribed.

5. Large entire maſſes of ores are ſometimes found in the ſtoney ſtrata of mountains. Theſe are improperly called *cumulated veins*, becauſe their length relatively to their breadth and depth, is not conſiderable.

6. Some inſtances are mentioned of *entire mountains*, conſiſting of ore. Such is the mountain Taberg in Smoland; and ſuch are the mountains of Kerunavara and Luoſavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. Theſe mountains conſiſt of iron-ore.

9. Laſtly, and chiefly, metals and ores are found in oblong tracts, forming maſſes called *veins*, which lie in the ſtoney ſtrata compoſing mountains.

The direction of veins greatly varies; ſome being ſtraight, and others curved. Their poſition alſo reſpecting the horizon is very various; ſome being perpendicular, ſome horizontal, and the reſt being of the intermediate degrees of declivity.

The dimenſions, the quality, and the quantity of contents, and many other circumſtances of veins, are alſo very various. Miners diſtinguiſh the ſeveral kinds of veins by names expreſſive of their differences. Thus veins are ſaid to be *deep*; *perpendicular*; *horizontal*, or *hanging*, or *dilated*; *rich*; *poor*; *morning*, *noon*, *evening*, and *night* veins, by which their direction towards that point of the compaſs where the ſun is at any of theſe diviſions of the natural day, is ſignified.

The ſtratum of earth or ſtone lying above a vein is called its *roof*: and the ſtratum under the vein is called its *floor*.

Some parts of veins are conſiderably thicker than others. Small veins frequently branch out from large veins, and ſometimes theſe branches return into the trunk from which they iſſued. Theſe veins, from which many ſmaller veins depart, have been obſerved to be generally rich.

Veins are terminated variouſly; 1. By a gradual diminution, as if they had been compreſſed, while yet ſoft, by ſuperincumbent weight; or by ſplitting and dividing into ſeveral ſmaller veins: or, 2. They are terminated abruptly, together with their proper ſtrata in which they lie. This abrupt termination of veins and ſtrata is occaſioned by their being croſſed by new ſtrata running tranſverſely to the direction of the former; or by perpendicular fiſſures through the ſtrata; which fiſſures are fre-

quently

with arſenic, nor with ſulphur, it is never found directly mineraliſed by theſe ſubſtances, as the other metals are. In the ſecond place, if it be mineraliſed

quently filled with alluvial matters, or with water, or are empty. Theſe perpendicular fiſſures ſeem to have been occaſioned by ſome rupture or derangement of the ſtratum through which the vein paſſes, by which one part of it has been raiſed or depreſſed, or removed aſide from the other, probably by earthquakes. Where the vein is terminated abruptly, it does not ceaſe, but is only broken and disjoined; and is often recovered by ſearching in the analogous parts of the oppoſite ſide of the deranged ſtratum. A principal part of the art of miners conſiſts in diſcovering the modes of theſe derangements from external marks, that they may know where to ſearch for the disjoined vein.

The *contents of veins* are metals and metalliferous minerals, as, the ſeveral kinds of ores, pyrites, blends, guhrs, vitriols; the ſeveral kinds of fluors, ſpars, quartz, hornblend, in which the ores are generally imbedded, or inveloped, and to which therefore the name, *matrix of the ore*, is applied; ſtalactites; cryſtallizations of theſe metalliferous and ſtoney ſubſtances encruſting the ſmall cavities of the circumjacent rock; and laſtly, water, which flows or drops through crevices in that rock.

In a vein, ores are found ſometimes attached to the rock or ſtratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and ſometimes both theſe kinds of adheſion occur in the ſame vein at different places. Frequently betwixt the matrix and the rock is interpoſed a thin cruſt of ſtone or of earth, called by authors the *fimbria of the ore*.

The *matrix* or the ſtone in which the ore lies inveloped is of various kinds in different veins. And ſome kinds of ſtone ſeem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, ſpar, fluors, and hornblend give reception to all ores and metals; but ſlates, chiefly to copper and ſilver, and never to tin; calcareous and ſparry matrixes, to lead, ſilver, and tin; and mica to iron.

Veins lie in ſtrata of different kinds of ſtone; but more frequently in ſome kinds of ſtone than in others. [illegible]s of the ſimple or uncompounded ſtones which compoſe ſtrata, the following are metalliferous: *calcareous ſtones*; *ſlaty ſand-ſtone* (cos fiſſilis arenoſus Wallerii); *feltſpar* (ſpatum pyrimachum ſive ſcintillans); *quartz*; ſometimes *jaſper*; frequently *ſlates*; and chiefly *micaceous* or *talky* ſtones; and *hornblend* (lapis corneus Wallerii; bolus indurata particulis ſquamoſis Cronſtedt). No veins have been found in gypſeous or in ſiliceous ſtrata, altho' *chertz* and *flints* frequently contain metallic particles, and ſome inſtances have been obſerved of ores of ſilver and of tin in *alabaſter*. Of compound ſtones, thoſe are ſaid to be chiefly metalliferous which conſiſt of particles of hornblend. Veins have alſo been found in the *red granite*; but ſeldom, if ever, in any other *granite*, or in *porphyry*. In general, veins are more frequently found in ſoft, fiſſile, and friable ſtrata, than in thoſe which are compact and hard.

A vein ſometimes paſſes from one ſtratum into the inferior contiguous ſtratum. Sometimes even the veins of one ſtratum do ſo correſpond with thoſe of an inferior ſtratum, the contiguity of which with the former is interrupted by a maſs of different matter through which the veins do not paſs, that they ſeem originally to have been continued from one ſtratum to the other. Thus in the mines of Derbyſhire, where the veins lie in ſtrata of limeſtone, the contiguity of which ſtrata with each other is interrupted in ſome places by a blue marle or clay, and in other places by a compound ſtone called *toadſtone*; the veins of one ſtratum frequently correſpond with the veins of the inferior ſtratum of limeſtone, but are never continued through the interpoſed clay or toadſtone. But we muſt obſerve, that theſe interpoſed maſſes, the blue marle, clay, and toadſtone, have not the uniform thickneſs obſervable in regular ſtrata, but are (eſpecially the toadſtone) in ſome places a few feet in depth, and in others ſome hundreds of yards. The above diſpoſition ſeems to indicate, that theſe ſeveral ſtrata of limeſtone have been originally contiguous; that the veins now disjoined have been once continued; that theſe ſtrata of limeſtone have been afterwards ſeparated by ſome violent cauſe, probably by the ſame earthquakes which have in a ſingular manner indirectly by the union it contracts with other metals naturally combined with ſulphur and arſenic, ſo ſmall a quantity of it only is found in theſe ores, that they ſcarcely even deſerve the name of *improper ores of gold.*

ner ſhattered the ſtrata of this mountainous country; that the interſtices thus formed between the ſeparated ſtrata have been filled up with ſuch matters as the waters could inſinuate, probably with the mixed comminuted ruins of ſhattered ſtrata; and, laſtly, that theſe ſhattered ſtrata have conſiſted of argillaceous and of calcareous earths, as appears from the clay; from the marle, which is a mixture of clay and calcareous earth; and from the toadſtone, which conſiſts of particles of hornblend (which Mr. Cronſtedt juſtly conſiders as an indurated bole or clay) mixed with particles of calcareous earth.

To the above hiſtorical ſketch of mines we ſhall add ſome conjectural remarks concerning their *formation.*

Thoſe ores which are found under water (I.); upon the ſurface of the earth (III.); in fiſſures of mountains and ſubterranean cavities, accumulated, but not accreted to the contiguous rocks, (IV. 4.) ſeem from their looſe, unconnected, broken appearance, to have been conveyed by alluvion.

All martial ochres have probably been ſeparated from vitriolic ferruginous waters (II.) either ſpontaneouſly or by calcareous earth; and theſe waters ſeem to have acquired their metallic contents by diſſolving the vitriol which is produced by the ſpontaneous decompoſition of martial pyrites. The ochres of copper, zinc, and perhaps of ſeveral other metals, have probably been precipitated from vitriolic waters by ſome ſubſtance, as calcareous earth, more diſpoſed to combine with acids; and theſe vitriolic waters have probably been rendered metalliferous, by diſſolving the vitriols produced by a combuſtion of cupreous pyrites, and of blend; for theſe minerals are not, as martial pyrites is, ſuſceptible of decompoſition, ſpontaneouſly, or by air and moiſture.

The metalliferous nodules and ſpots (IV. 1.) ſeem to have been infixed in ſtones while theſe were yet ſoft. Perhaps the metalliferous and lapideous particles were at once diſſolved and ſuſpended in the ſame aqueous menſtruum, and during their concretion, cryſtallized diſtinctly, as different ſalts do, when diſſolved in the ſame fluid.

The earths and ſtones uniformly colored by metals (IV. 2.) were alſo probably in a ſoft ſtate while they received theſe tinges. The opake-colored ſtones ſeem to have received their color from metallic calxes mixed and diffuſed through the ſoft lapideous ſubſtance; and the tranſparent-colored ſtones have probably received their colors from vitriolic ſalts, or from metallic particles diſſolved in the ſame water which ſoftened or liquefied the ſtony ſubſtance; which metallic ſalts and particles were ſo much diffuſed, that they could not be diſtinctly cryſtallized. That all ſtones have been once liquid and diſſolved in water, appears probable not only from their regular cryſtallized forms, but alſo from the ſolubility of ſome ſtones, as of gypſeous and calcareous earths, in water; and from the water which we know is contained in the hardeſt marbles, as well as in alabaſters; to which water theſe ſtones owe the cryſtallization of their particles.

*The veins called *cumulated*, (IV. 5.) and the entirely metalliferous mountains (IV. 6.) are believed by Wallerius to be analogous to the nodules (IV. 1.). Theſe metalliferous ſubſtances ſeem to have been originally formed or concreted in the places where they are found.

The metalliferous ſtrata (IV. 3.) have probably been inſinuated between the lapideous ſtrata, after the ſeparation of theſe from each other by ſome violent cauſe; in the ſame manner in which we ſuppoſed that the clay and toadſtone have been inſinuated betwixt the ſeveral ſtrata of limeſtone in Derbyſhire. The matters thus inſinuated may have been either fluid, which would afterwards cryſtallize, and form entire regular maſſes; or they may have been the ruins of ſhattered ſtrata and veins brought by waters, and there depoſited; in which caſe they will appear broken and irregular. Theſe metalliferous ſtrata, although frequently confounded with the horizontal or dilated veins, may be diſtinguiſhed, according to Wallerius, from theſe by the following properties: 1. They are generally thinner and much broader than the veins called dilated. 2. They are ſeldom found at a greater depth than a hundred perches, and generally in the neighbourhood

of

Hence gold is found either in its natural ſtate, of a certain degree of purity, poſſeſſed of all its properties, or engaged with ſome other metals in certain minerals.

of veins, from which they probably have received their contents. 3. From their want of the thin encruſtations called *fimbriæ*, which, we obſerved, are frequently interpoſed betwixt the rock and the ore or its matrix; and from their want of the other properties of veins.

But in *veins*, properly ſo called, the ſtrongeſt marks exiſt of ores having been there concreted, and not depoſited in their preſent ſtate. Their regular, unbroken appearance, their accretion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix inveloping the ore, the frequent cryſtallization of the ore and of the other contents of the vein, indicate, that ores, as well as the other ſolid contents, have been there concreted from a fluid to a ſolid ſtate.

Moſt authors believe, that veins, and the perpendicular clefts in the ſtony ſtrata of mountains, called *Fiſſures*, have been produced by the ſame cauſe; or rather, they conſider veins only as fiſſures filled with metalliferous matters. They further believe, that fiſſures have been occaſioned by the exſiccation of ſtrata, while theſe were paſſing from a fluid to a ſolid ſtate. Wallerius thinks, that fiſſures have been formed from exſiccation, but that veins were channels made through the ſtrata, while yet ſoft and fluid, by water, or by the more fluid parts of the ſtrata penetrating and forcing a paſſage through the more ſolid parts. He thinks, that theſe fluid parts conveyed thither their metalliferous and ſtony contents, which were there coagulated or concreted. He ſupports his opinion by obſerving, that all the veins of the ſame ſtratum generally run parallel to each other; that they frequently bend in their courſe; that the ſame vein is ſometimes contracted and ſometimes dilated; that veins are frequently terminated by being ſplit or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fiſſures are always wideſt at top and are very narrow below: all which appearances, he thinks, could not have been produced by exſiccation. From theſe reaſons, fiſſures appear to have had a different, and from the disjunction and rupture of veins croſſed by fiſſures, they ſeem to have had a later origin than veins. Whether fiſſures could have been produced by the very gradual exſiccation of theſe large maſſes of ſtrongly coherent matter; or whether they have been produced by the ſame violent cauſes, namely, earthquakes, by which the ſtrata in which fiſſures are generally found have been broken and deranged, and by which metalliferous mountains themſelves have been formed, or their ſtrata raiſed above their original level; as ſome authors have, with great probability, conjectured; I do not pretend to determine.

Veins are ſeldom, if ever, found but in mountains. The reaſon of which may not improbably be, that in metalliferous mountains we have acceſs to the more ancient ſtrata of the earth, which in plains are covered with ſo many depoſited, alluvial, and other later ſtrata, that we can ſeldom, if ever, reach the former. That theſe mountains conſiſt of ſtrata which have been originally lower than the upper ſtrata of adjacent plains, appears from an obſervation which has been made, that the ſtrata of mountainous countries dip with more or leſs declivity as they approach the plains, till they gradually ſink under the ſeveral ſtrata of thoſe plains, and are at laſt immerſed beyond the reach of miners. This leading fact in the natural hiſtory of the earth has been obſerved by a ſagacious philoſopher, *Mr. Mitchell*, in his *Conjectures concerning Earthquakes, &c. Philoſ. Tranſ.* 1760.

That the inferior ſtrata of the earth contain large quantities of pyritous, ſulphureous, and metalliferous matters, appears, 1. From the ſubterranean fires in thoſe inferior ſtrata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniouſly conjectures). 2. From the obſervation, that all kinds of mountains are not equally metalliferous; but that veins, eſpecially, are only found in thoſe mountains, which, being compoſed of very ancient ſtrata, are called *primæval*, which form the chains and extenſive ridges on the ſurface of the earth, which direct the courſe of the waters, and which conſiſt of certain ſtrata, The gold which is found alone is called *native* or *virgin gold*. This is generally incruſted, and fixed in different kinds of ſtones, principally in flints

the thickneſs of each of which, its generic qualities, and its poſition relatively to the other ſtrata, are, in different parts of the chain of mountains where that ſtratum is found, nearly uniform and alike, notwithſtanding that the numbers, and the inclinations of the ſtrata compoſing contiguous mountains, or even different parts of the ſame mountain, are often very various; and therefore that veins are ſeldom, if ever, found in the mountains called by authors *diluvial* and *temporary*, which are ſingle, or detached, which conſiſt not of ſtrata uniformly diſpoſed, but of alluvial maſſes, in which fragments of ores may be ſometimes, but veins never, found. Nevertheleſs, ſingle, and ſeemingly detached, mountains in ſmall iſlands have ſometimes been found to be metalliferous. But we muſt obſerve, that theſe mountains conſiſt of uniform ſtrata; that iſlands themſelves, eſpecially ſmall iſlands, may be conſidered as eminent parts of ſubmarine ranges of mountains; and that the mountains of ſuch iſlands may be conſidered as apices or tops only of inferior mountains.

Thoſe mountains are ſaid to be moſt metalliferous which have a gentle aſcent, a moderate height, and a broad baſis, the ſtrata of which are nearly horizontal, and not much broken and disjoined. In theſe mountains, at leaſt, the veins are leſs interrupted, more extended, and conſequently more valuble to miners than the veins in lofty, craggy, irregular, and ſhattered mountains.

Authors diſpute concerning the time in which ores have been formed, ſome referring it to the creation of the world, or to the firſt ſubſequent ages; and others believing, that they have been gradually from all times, and are now daily, formed. From the accretion of ores and of their matrices to their proper rocks, and from the inſertion of metalliferous nodules and ſtriæ in the hardeſt ſtones, we are inclined to believe, that the matter of theſe veins and nodules are coeval with the rocks and ſtones in which they are inveloped. Nevertheleſs, we cannot doubt that ſmall quantities, at leaſt, of ores are ſtill daily formed in veins, fiſſures, and other ſubterranean cavities. Several well atteſted inſtances confirming this opinion are adduced by authors: Cronſtedt mentions an incruſtation of ſilver-ore that was found adhering to a thin coat of lamp-black, or of ſoot, with which the ſmoke of a torch had ſoiled a rock in a mine at Koningſberg in Norway; and that this incruſtation of ſilver-ore had been formed by a metalliferous water paſſing over the rock. Lehman affirms, that he poſſeſſes ſome ſilver-ore attached to the ſtep of a ladder, found in a mine in Hartz, which had been abandoned two hundred years ago; and that ſeveral ſteps of ladders ſimilarly encruſted had been found. Many other inſtances are mentioned by authors, of galena, pyrites, ſilver-ores, and other metalliferous ſubſtances, having been found adhering to wood, to foſſil-coal, to ſtalactitical encruſtations, to oyſter-ſhells, and other recent ſubſtances. From theſe, and from ſimilar inſtances which I have ſeen, I am induced to believe, that not only ochres and fragments of ores may, with other alluvial matters, be now daily depoſited, but alſo that ſmall quantities of mineraliſed ores are recently formed; although many hiſtories mentioned by Becher, Barba, Henckel, and other authors, of the entire renovation of exhauſted veins, and eſpecially thoſe of the growth and vegetation of metals and of ores, appear to be at leaſt doubtful.

Various opinions have been publiſhed concerning the formation of mineraliſed ores. According to ſome, theſe ores were formed by congelation of the fluid maſſes found in mines, called *Guhrs*. *See* GUHR. Other authors believe, that ores have been formed by the condenſation of certain mineral, metallic, ſulphureous, and arſenical vapors, with which they ſuppoſe that mines abound. Some have even affirmed, that they have ſeen this vapor condenſe, and become in a few days changed into gold, ſilver, and other metallic matters: but the exiſtence of ſuch vapors is not aſcertained; for the noxious vapors commonly ſuppoſed to be ſulphureous, arſenical, and metalline, are nothing but the permanently elaſtic vapors called *inflammable* and *uninflammable fixable airs*. *See* DAMPS.

Whether the component parts of ores have been once reduced to a ſtate of vapor, and quartz. Mr. Cramer ſays, that the yellow brilliant ſpots of the blue ſtone, called *lapis lazuli*, are native gold; but theſe are very ſmall. (c)

Gold is alſo found in fat and muddy earths; and Mr. Cramer affirms, that ſcarcely any ſand can be found which does not contain gold; but he acknowledges, at the ſame time, that the quantity is too ſmall to compenſate for the expence of obtaining it.

Laſtly, the largeſt quantity of native gold is to be found in the ſands of ſome rivers. It is chiefly collected in hollows at the bottom of theſe rivers, and at their ſeveral bendings. The gold is collected in theſe places by a natural operation, ſimilar to that of waſhing of ores.

A conſiderable quantity of gold is in the ſand of ſeveral rivers in France; ſo that perſons who collect it find enough to compenſate their trouble. Mr. Reaumur, in a Memoir that he gave in the year 1718 concerning the Rivers of France which contain gold, enumerates ten of them, namely, the Rhine, the Rhone, the Doux, the Ceze, and the Gardon, the Arriege, the Garonne, two ſtreams which flow into the Arriege, called Ferriet and Benagues; laſtly, the Salat, the ſource of which is in the Pyrenean mountains.

The Ceze is the river which furniſhes the largeſt quantity of gold at certain times. Mr. Reaumur obſerves, that its particles are larger than thoſe of the Rhine and of the Rhone, and ſays, that in ſome days a peaſant will find gold to the value of a piſtole, and in others will ſcarcely find any.

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and in that ſtate have been united; or whether theſe parts were conveyed to veins already combined, but in a fluid ſtate; or by what natural proceſs they have been brought together and united, we have not ſufficient data to inveſtigate and determine.

We can indeed by analyſis diſcover what theſe component parts of ores are; and we can even imitate many ores by fuſing together thoſe parts: but, from the regularity of the forms and ſtructures of ores, the union of their component parts muſt have been accompliſhed by a more gradual proceſs; and, although it be difficult to explain how ores could be diſſolved in a watery menſtruum, and afterwards cryſtallized, ſo as to form the regular maſſes which they now conſtitute; yet when we conſider how many ſolutions and decompoſitions are effected by the very ſlow and gradual operations of nature, which cannot be effected by thoſe of art, the conjecture (if, in a ſubject ſo obſcure, and concerning which neither ſufficient facts have been diſcovered, nor is the life of man ſufficiently long to make obſervations and experiments, conjectures may be admitted) ſeems not improbable that ores, and perhaps all other mineral cryſtallized matters, as ſpars, cryſtals, fluors, &c. have been once diſſolved in an aqueous menſtruum, by evaporation of which they have been afterwards concreted and cryſtallized. An inſtance of the formation of ſilver-ore from a metalliferous water has already been quoted from a Memoir in the Swed. Act. by Mr. Cronſtedt. The liquors called *guhrs*, found in mines, are known to contain frequently, beſides metallic matters, alſo calcareous and gypſeous particles. By intervention of theſe earthy matters, may not alſo ſulphur be diſſolved in water, and thus a hepar, the moſt powerful ſolvent of metallic ſubſtances, be formed? If we ſuppoſe ſuch a hepar impregnated with metallic particles to be collected in a ſubterranean cavity, where the water might be exceedingly ſlowly evaporated, till no more remained than was ſufficient for the cryſtallization of the ſolid matters, might not theſe matters then ſeparate and cryſtallize diſtinctly; the earthy ſubſtances firſt concreting, and forming ſpars, fluors, and other matrixes, which would adhere to the ſolid rock, while the ſulphureous, arſenical, and metallic ſubſtances ſhould afterwards concrete together, and compoſe ores which would adhere to the matrixes previouſly formed?

(c) Concerning theſe, *ſee* LAPIS-LAZULI.

The native gold found in rivers or elſewhere is never perfectly pure, or of twenty-four karats. It always contains a certain quantity of allay, which is generally ſilver. The gold of our rivers, according to Mr. Reaumur's trials, was found to be from eighteen to twenty-two karats, that of the Ceze being the loweſt, and that of the Ariege being the pureſt. (*d*).

DXI. ORES *of* PLATINA. Platina is very rare, and has been but lately diſcovered. As, like gold, it cannot be allayed with ſulphur or with arſenic, probably no ore properly ſo called exiſts of this metal. Accordingly,

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(*d*) ORES *of* GOLD. Although gold cannot be directly diſſolved by ſulphur, yet it probably may be mineraliſed by the intervention of other metallic matters. Thus, although no proper ore of gold exiſts, yet it is found in ſeveral mineral ſubſtances, in which it is always accompanied, as Cramer affirms, with a much larger quantity of ſilver; to which latter metal that author attributes its mineraliſed ſtate. The minerals containing gold are blend, cupreous and arſenical pyrites, ore of antimony, cinnabar, white ore of arſenic, vitreous and other ſilver ores, and the lead-ore called galena.

Gold is more frequently imbedded in quartz than in any other matrix, but it is alſo found in limeſtone and in hornblend. Gold mines are in general very precarious, as they do not form regular veins, nor is the gold uniformly diſtributed through a matrix.

Becher and Cramer think, that no ſand is entirely free from gold. The yellow, red, black, and violet-colored ferruginous, are ſaid to contain moſt gold. Mr. Hellot relates, that in eleven eſſays of one kind of ſand, from a quintal, or 921600 grains, were obtained each time from 848 to 844 grains of noble metal, excluſive of the gold which remained in the ſcoria; and that of the metal thus obtained two thirds were gold, and the remaining third was ſilver. He ſays, that parcels of ſand taken up at very ſmall diſtances from each other contained very unequal proportions of gold.

The gold found in ſands is generally leſs pure than that which is imbedded in a ſolid matrix. Reaumur ſays, that a piece of gold, weighing 448 ounces, was ſhewn to the Royal Academy at Paris, which was found upon eſſay to have different fineneſs in different parts of the maſs.

Ores and earths containing gold may be eſſayed by the methods directed for the extraction of gold from large quantities of theſe auriferous matters (*ſee* SMELTING *of* ORES): or they may in general be eſſayed by being fuſed in a cupel or teſt, placed under the muffle of an eſſay-furnace, or in a crucible placed in an air-furnace, with eight or ten times their quantity of lead, if they be fuſible; and with a larger quantity of lead, if they be difficultly fuſible; and by ſcorifying the earthy matters, while the lead becomes impregnated with the noble metals. Theſe operations are entirely ſimilar to thoſe employed for the ſeparation of ſilver from its ores by precipitation with lead; *a detail of which ſee ſubjoined under the article* ORES *of* SILVER, *in a Note* [*Proceſſes* I. III. IV. V. VI]. Theſe metals are afterwards to be ſeparated from the lead by cupellation, in the manner directed in the articles, ESSAYS *of the* VALUE *of* SILVER, *and of* GOLD. The gold is then to be ſeparated from the ſilver by the proceſſes deſcribed in the article PARTING.

The quantity of lead to be added to the ore in this eſſay muſt be ſuch as renders the ſcoria very thin, that the whole gold may be imbibed by the lead. Some iron-ores containing gold cannot be reduced into a ſcoria ſufficiently thin with ſixteen times their quantity of lead, unleſs the heat be, at the ſame time, conſiderably encreaſed. When the ore is exceedingly refractory, the ſcorification ought to be promoted by adding to it four times its quantity of tartar, twice its quantity of nitre, and four times its quantity of litharge. This mixture is to be put in a good eſſay-crucible, and covered with ſea-ſalt. The crucible is to be ſet in a forge-hearth, and expoſed gradually to heat, till the ſcoria has acquired ſufficient fluidity, and the lead has imbibed the noble metal.

See the methods which have been uſed for eſſaying auriferous ſands, under the article SMELTING *of* ORES.

in the only mines of platina which we know, namely, the gold mines of Santafe near Carthagena, the platina is found native like the gold, and in its metallic ſtate.

DXII. **ORES *of* SILVER.** Next to gold, ſilver is the metal moſt frequently found in its metallic ſtate, that is, not mineraliſed by ſulphur or by arſenic. This ſilver, called alſo *native* or *virgin*, generally affects ſome regular form, and conſiſts of filaments or vegetations of various figures. Native ſilver, like gold, is incruſted, or adherent to ſeveral kinds of ſtones. It is generally allayed with ſome gold: but ſilver, like all the other metals, is much more frequently found mineraliſed by ſulphur and by arſenic. (*e*)

Three principal proper ores of ſilver are known, which are very rich, but very rare. Theſe are;

1. The *vitreous ſilver ore.* This ore has no determinate figure, and has nearly the color, ſoftneſs, and fuſibility of lead. It is very heavy, and contains three quarters of its weight of pure ſilver. In this ore the ſilver is mineraliſed by ſulphur alone. Some expert artiſts imitate it very well by combining ſulphur with ſilver by fuſion in a crucible. (*f*)

2. The *horny* or *corneous ſilver ore.* This ore is ſo called from its color and ſemitranſparency, by which it reſembles horn or colophony. This ore, being ſuddenly heated, crackles, as almoſt all ores do, and melts with a gentle heat. Two-thirds of it are ſilver, which is mineraliſed by ſulphur and arſenic. This ore is very rare. Wallerius ſays, after Woodward, that it is found at *Johann-Georgen-Stadt* in *Saxony*. (*g*)

3. *Red ſilver ore*, called alſo *Roſiclare*. Its color is more or leſs red; it is ſometimes cryſtallized, very heavy, and is fuſible like the above-mentioned ores. In this ore the ſilver is mineraliſed by arſenic and by ſulphur, but chiefly by the former. It alſo contains a little iron, and furniſhes two-thirds of its weight of ſilver. Its red color may proceed either from the iron it contains, or from the mixture of arſenic and ſulphur, or, laſtly, from the particular manner in which the arſenic is united with the ſilver, an example of which we

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(*e*) ORES *of* SILVER. *Native ſilver* is found in form of plates, of fibres, or of grains, or cryſtallized. It lies generally in quartz, flint, ſpar, ſlate, cobalt, and in ſilver-ores. It is ſometimes enveloped in a thin ſtony cruſt.

(*f*) The *vitreous ore*, according to Cronſtedt, is either in form of plates or of fibres, or is cryſtallized, or has no determinate figure. It may be imitated by adding about five parts of ſulphur to one part of melted ſilver; in which operation moſt of the ſulphur is conſumed: or it may be imitated by expoſing a plate of ſilver red-hot to the fumes of burning ſulphur.

(*g*) *Corneous ore* has various colors; white, pearly, brown, yellow, greeniſh, or reddiſh. It is foliated and ſemitranſparent. It is ſomewhat ductile, and fuſible with the flame of a candle. When heated, it emits, as Wallerius ſays, a ſulphureous and blue flame, and, according to Cramer, alſo a very ſmall quantity of an arſenical fume. Wallerius ſays, that it contains two-thirds of ſilver, with a conſiderable quantity of ſulphur and a ſmall quantity of arſenic. Lehman thinks, that it is ſilver united with a little arſenic. But Mr. Cronſtedt ſays, that it is a luna cornea, or ſilver combined with marine acid; and that it is incapable of being decompoſed but by ſubſtances which can unite with that acid. This latter opinion ſeems to be the moſt probable, as the ore, according to its deſcription, is ſimilar to luna cornea, and as it cannot be imitated by any mixture of ſulphur and of arſenic with ſilver. The blue flame, and the ſmell ſlightly arſenical, which are emitted from heated corneous ore, are alſo obſervable from every combination of marine acid with a ſubſtance containing phlogiſton.

have in the red precipitate of ſilver made by the neutral arſenical ſalt. *See* ARSENIC *and* SALT (NEUTRAL ARSENICAL). (*h*)

Beſides theſe, many other minerals are called ſilver ores, but which are only improper ores of ſilver as they contain a larger quantity of ſome other metal (*i*).

(*h*) *Red ſilver ore* is either plated or ſolid, or cryſtallized, and frequently ſemitranſparent. Its color is various, from a dark grey to a deep red, according to the proportions of the two mineraliſing ſubſtances. It crackles and breaks in the fire, exhales an arſenical fume, and is readily fuſed. It is found generally in quartz, ſpar, cryſtal, hornblend.

(*i*) Beſides the three ſilver-ores above deſcribed, the following ores contain ſilver mixed with other metals.

1. *Grey ſilver ore.* This contains copper and ſilver mineraliſed by arſenic and ſulphur, and generally more of the former than of the latter metal; but as it is valued chiefly for the ſilver, it has been generally enumerated amongſt ſilver ores.

2. *White ſilver ore* is an arſenical pyrites containing ſilver.

3. *Black ſilver ore* contains ſulphur, arſenic, copper, iron, ſometimes lead, and about a fourth part of ſilver, according to Wallerius.

4. *Plumoſe ſilver ore* is white or black, ſtriated like plume-alum, or like ore of antimony. It is ſilver mineraliſed by ſulphur, arſenic, and antimony.

5. *Pech-blend.* In this blend ſilver, gold, and zinc, are mineraliſed by ſulphur, probably by intervention of iron, by which the gold and zinc are rendered capable of uniting with the ſulphur.

6. Silver is frequently found in *galena*; and ſometimes in *martial pyrites*; in the *red ore of arſenic*; in various *ores of copper*, *lead*, *tin*, *iron*, and eſpecially *cobalt*; in *blends*; in *yellow* or *red earths*; in *black* and *blue baſaltes*; and alſo in *ſtrata of ſtones*, which do not appear externally to contain any mineral ſubſtance.

7. *Liquid ſilver ore*, or *guhr of ſilver*, is a grey or whitiſh liquid maſs which contains, as Wallerius ſays, either native ſilver, or ſome fluid ſubſtance capable of producing it. Mr. Cronſtedt mentions, in the Swediſh Memoirs, a water flowing through a mine in Norway containing ſilver. Another inſtance is alſo mentioned of a ſilver guhr, in the Act. Erud. Upſal. 1720.

8. Mr. Von Juſti pretends, that he has found ſilver mineraliſed by an *alkaline ſubſtance*; but he has not ſpoken ſufficiently diſtinctly concerning it, to know whether he means a ſaline or earthy alkaline matter. Henkel alſo pretends, that by treating calcareous earth or certain clays with pyrites, ſilver may be obtained.

Ores of ſilver may be eſſayed [*ſee the article* ESSAY *of* ORES] by the ſame methods which are employed for the extraction of that metal from large quantities of ores; which methods are different, and ſuited to the different qualities of the ſeveral ores. *See* SMELTING *of* ORES. Or, in general, ores and earths containing ſilver may be eſſayed by the following Proceſſes, which are copied from Dr. Mortimer's Engliſh edition of *Cramer's Art of Eſſaying Metals*, *Part* II. *Proceſs* 1.

PROCESS I.

To precipitate Silver by means of Lead from fuſible Ores.

" POUND the ore in a very clean iron-mortar into fine powder: of this weigh one docimaſtical centner or quintal, and eight of the like centners of granulated lead.

" Then have at hand the docimaſtical teſt (*ſee* PLATE I.), which muſt not as yet have ſerved to any operation: pour into it about half of the granulated lead, and ſpread it with your finger through the cavity of it.

" Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

" Put the teſt thus loaded under the muffle of an eſſay-furnace, and in the hinder part of it: then make your fire, and encreaſe it gradually. If you look thro' the holes of either of the ſliders, you will ſoon ſee that the pounded ore will be raiſed out of the melted lead, and ſwim upon it. A little after, it will grow clammy, melt, and be thrown towards the border of the teſt: then the ſurface of the lead will appear in the middle of the teſt like a bright diſc, and you will ſee it ſmoak and boil: ſo ſoon as you ſee this, Such are the *blue ſilver-ore*, which is only a lead-ore containing much ſilver, and the *grey ſilver-ore*, which is a copper-ore containing ſilver.

"it will be proper to diminiſh the fire a ſmall matter for a quarter of an hour; ſo as that the boiling of the lead may almoſt ceaſe. Then again, encreaſe the fire to ſuch a degree, that all may turn into a thin fluid, and the lead may be ſeen, as before, ſmoaking and boiling with great violence. The ſurface of it will then diminiſh by degrees, and be covered over with a maſs of ſcorias. Finally, have at hand an iron hook ready heated, wherewith the whole maſs muſt be ſtirred, eſpecially towards the border; that in caſe any ſmall parcels of the ore not yet diſſolved ſhould be adherent there, they may be brought down, taking great care not to ſtir any the leaſt thing out of the teſt.

"Now, if what is adherent to the hook during the ſtirring, when you raiſe it above the teſt, melts quickly again, and the extremity of the hook grown cold is covered with a thin, ſmooth, ſhining cruſt; it is a ſign that the ſcorification is perfect; and it will be the more ſo as the ſaid cruſt adherent to the hook ſhall be colored equally on every ſide: but in caſe, while the ſcorias are ſtirred, you perceive any conſiderable clammineſs in them, and when they adhere in good quantity to the hook, though red-hot, and are inequally tinged, and ſeem duſty or rough with grains interſperſed here and there; it is a ſign that the ore is not entirely turned into ſcorias. In this caſe, you muſt with a hammer ſtrike off what is adherent to the hook, pulverize it, and with a ladle put it again into the teſt, without any loſs or mixture of any foreign body, and continue the fire in the ſame degree till the ſcoria has acquired its perfection, and the above-mentioned qualities. This once obtained, take the teſt with a pair of tongs out of the fire, and pour the lead, together with the ſcoria ſwimming upon it, into a cone made hot and rubbed with tallow. Thus will the firſt operation of the proceſs be performed, which does not commonly indeed laſt above three quarters of an hour.

"With a hammer ſtrike the ſcorias off from the regulus grown cold, and again examine whether they have the characteriſtics of a perfect ſcorification; if they have, you may thence conclude, that the ſilver has been precipitated out of the ore turned to ſcorias, and received by the lead."

"When the ſcorification laſts longer than we mentioned, the lead at laſt turns to ſcorias or litharge, and the ſilver remains at the bottom of the veſſel: but the fire muſt be moderately ſupplied, and the veſſels be extremely good, to produce this effect; for they ſeldom reſiſt to the ſtrength of the ſcorias long enough; ſo that the whole ſcorification may be brought to an end; which has afterwards this inconveniency, that the ſilver is diſſipated by grains in the ſmall hollows of the corroded ore, and can hardly be well collected again, when the ore has but little ſilver in it. Nay, there is ſtill more time to be conſumed to obtain the perfect deſtruction of the lead, by means of the combined actions of the fire and air, becauſe the ſcorias ſwimming at the top retard it conſiderably.

"In this proceſs, the ſulphur and the arſenic of the ſilver-ore, when the ore is broken ſmall, and extended widely in a ſmall quantity, are in part eaſily diſſipated by the fire, and in part abſorbed by the lead; the lighter part of which, ſwimming upon the heavier, becomes very clammy by means of the ſulphur which is in the ore; but when this is diſſipated by the violence of fire, it turns into glaſs or ſcorias: but when arſenic is predominant in the ore, the plumbeous part turns immediately into a very penetrating and very fuſible glaſs, having a diſſolving efficacy, unleſs the arſenic lies hidden in a white pyrite or cobalt. For this reaſon, the fixed part of the ore, which is no ſilver, is diſſolved by that glaſs, melts, and aſſumes the form of ſcorias. The unmetallic earths and the pure copper or lead-ores thereto adherent are of this kind. The ſilver then remains immutable, and being freed of theſe heterogeneous bodies, which are partly diſſipated and partly melted, it is precipitated and received by the remain-

DXIII. ORES *of* COPPER. Copper is found under ground

"ing regulus of lead. Therefore this proceſs is completed by three diſtinct operations; viz. 1. By roaſting. 2. By ſcorification. 3. By the melting precipitation of the ſilver, which is the reſult of the two former operations.

"The ore muſt be pulveriſed very fine in order to encreaſe the ſurface, that the diſſipation of the volatiles and the diſſolution by litharge may be ſooner effected. This pulveriſing muſt then be done before the ore is weighed, becauſe there is always ſome part of the ore adherent to the mortar or iron-plate on which it is made fine; which part being loſt, the operation is not exact. *Erker* was in the right when he preſcribed eight centners of lead for the ſubduing of fuſible ores. Nevertheleſs, it muſt be owned that this quantity is ſuperfluous in ſome caſes. However, as the fluxibility of the ſilver-ore depends from the abſence of ſtones, pyrites, &c. it is eaſy to ſee, that there are an infinite number of degrees of fluxibility which it would be needleſs to determine exactly, and moſt commonly very difficult to determine by the bare ſight. Beſides, a little more lead does not render the proceſs imperfect; on the contrary, if you uſe too ſmall a quantity of lead, the ſcorification is never completely made. Nay, there are a great many ores, containing ſulphur and arſenic in plenty, that deſtroy a conſiderable quantity of lead: ſuch are the red ſilver-ore, and that wherein there is a great deal of the ſteel-grained lead ore. If the fire muſt be ſometimes diminiſhed in the middle of the proceſs, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead, from penetrating the pores of the teſt, and from corroding it; which is eaſily done when the fire is over-ſtrong; for then the ſurface of the veſſel which is contiguous to the lead contracts cavities, or being totally conſumed by ſmall holes, lets the regulus flow out of it. The veſſels that are moſt ſubject to this inconvenience are thoſe in the materials of which lime, plaſter, and chalk are mixed. Nay, theſe bodies, which are of their nature refractory, being eroded during their ſcorification, at the ſame time, communicate a great clammineſs to the ſcoria; ſo that a great quantity of the maſs remains adherent to the teſt in the form of protuberances, when you pour it out; whereby a great many grains of the regulus are detained."

PROCESS II.

THE regulus obtained by the proceſs I. contains all the ſilver of the ore, and the unſcorified part of the lead. The ſilver may be afterwards ſeparated from the lead, and obtained pure by *cupellation*; which proceſs is deſcribed under the article of the Dictionary, ESSAY *of the* VALUE *of* SILVER.

PROCESS III.

IF the ſilver-ore cannot be waſhed clean, or if it be rendered refractory by a mixture of unmetallic earths and ſtones, the ſcorification of theſe earthy matters frequently cannot be completed by the proceſs I. Cramer therefore directs that ſuch ores ſhall be treated in the following manner [*Art of Aſſaying*, *Part* II. *Proceſs* 3].

"Bruiſe the ore into an impalpable powder, by grinding in a mortar; to a docimaſtical centner of it, add a like quantity of glaſs of lead finely pulveriſed; for the more exactly theſe two are mixed together, the more eaſily the ſcorification afterwards ſucceeds. Put this mixture, together with twelve centners of lead, into the teſt, according to proceſs I. then put the teſt under the muffle.

"Make firſt under it a ſtrong fire, till the lead boils very well; when you ſee it ſo, diminiſh the violence of the heat, as was directed in the firſt proceſs; but keep it thus diminiſhed a little longer: then, finally, again encreaſe the fire to ſuch a degree, till you perceive the ſigns of a perfect ſcorification and fuſion. *See the whole Proceſs* I. Now this proceſs laſts a little longer than the foregoing, and requires a greater fire towards the end.

"It ſometimes happens that a very refractory ore cannot be diſſolved by litharge; and that a maſs, which has the clammineſs in three different forms. 1. Native or virgin copper diverſely ramified, which

of pitch, ſwims upon the regulus and upon the ſcorias themſelves which are already ſubdued in part: when you ſee this, ſhut the vents of the furnace to diminiſh the fire; then gently touch this refractory body with a ſmall iron cold hook, to which it will immediately ſtick; take it off ſoftly, not to loſe any thing; pound it into a fine powder, adding a little glaſs of lead; and put it again into the teſt; then continue the ſcorification, till it is brought to its perfection. But you muſt always examine the ſcoria of your refractory ore, to ſee whether there may not be ſome grains of regulus diſperſed in it; for ſometimes the ſcorias that grow clammy retain ſomething of the metal; which if you ſuſpect, pound the ſcoria into a fine duſt, and thus the grains of metal will appear, if there are any left; becauſe they can never be pounded fine. The ſilver is ſeparated from this regulus by coppelling, as in Proceſs II.

“All earths and ſtones are refractory in the fire; for, although ſome of them melt naturally in the fire, as thoſe that are vitrifiable do; nevertheleſs, all the others, a very few excepted, melt much more difficultly than metals, and never become ſo thin in the fuſion as is required for the ſufficient precipitation of a precious metal. But litharge itſelf does not conveniently diſſolve theſe refractory matters by the help of fire alone, unleſs you add ſome mechanical mixture to them; for the very moment the ſaid litharge penetrates through the interſtices of the refractory ore, and begins to diſſolve it, a tenacious maſs is produced, which hardly admits any farther dilution by the litharge. You may ſee it plain, if you make colored glaſſes with metallic calxes; if you pour careleſsly upon them a calx that gives a color, you will never obtain that they may be equally died on every ſide, even altho' you ſhould torture them for whole days together in a great fire. Nay, glaſs already made can never be diluted by only pouring ſalts and litharge upon it. Wherefore, you muſt uſe the artifice of glaſs-makers, who in the making of the moſt perfect glaſſes, take great care before they put the ſpecies of their ingredients into the fire, to have a mechanical mixture precede, or at leaſt accede during the fuſion itſelf; which is done here by pounding glaſs of lead mixt with the ore: but if you think that your glaſs of lead is not ſufficiently fuſible, you may add to it litharge melted firſt, and then pounded into a fine powder.

“As this ſcorification requires a longer and a greater fire than the foregoing, and as a greater quantity of litharge is moreover requiſite to ſubdue the refractory ſcoria; it is eaſy to ſee why a much greater quantity of lead muſt be uſed here than in Proceſs I. and, although leſs lead is often ſufficient, it is nevertheleſs proper always to uſe the greateſt quantity that can be neceſſary, leſt, for inſtance, it ſhould be neceſſary to try ſo many times the lead alone, to make it evident how much ſilver the lead when alone leaves in the coppel. Nor need you fear leſt any thing of the ſilver be taken away by the lead, provided the coppels be good, and the coppelling duly put in execution: for you can hardly collect a ponderable quantity of ſilver out of the collected fume of the lead, which riſes during the coppelling, as well as out of the litharge, that is withdrawn into the coppel.”

PROCESS IV.

IF the ore be rendered refractory by pyrites, Cramer directs, that the ſilver ſhould be precipitated by lead in the following manner. [*Art of Aſſaying*, Part II. *Proc.* 4.]

“Break your ore into a rough powder, and put a centner of it into the teſt: put upon this another teſt in the manner of a tile; put it under the muffle hardly red-hot: increaſe the fire by degrees. There will always be a crackling: which being ended, take away the upper teſt; for when the veſſels have been red-hot about one minute, the ore ceaſes to ſplit. Leave the ore under the muffle till the arſenic and the ſulphur are for the moſt part evaporated; which you will know from the ceſſation of the viſible ſmoak, of the ſmell of garlic, or the acid; then take away the teſt, and leave it in a place not too cold, that it may cool of itſelf.

“Pour out, without any diſſipation, the

is much more rare than native ſilver. This native copper is not ſo ductile as

“ roaſted ore, and with a knife take away what is adherent to the veſſel; pound it to a moſt ſubtile powder, and grind it together with an equal weight of glaſs of lead; and, finally, ſcorify the whole collected ore in the ſame teſt wherein the teſting was made, unleſs it has contracted chinks, as was deſcribed in Proceſs III.

“ *Remarks.* Yellow pyrites-ores contain a very great quantity of ſulphur, even greater than is neceſſary to ſaturate the metal that lies hidden in them. For which reaſon this ſuperfluous ſulphur diſſipates in a middling fire; but if it had been mixed with lead it would have rendered it refractory, nor could it afterwards be diſſipated from it without a conſiderable deſtruction of the lead. The white arſenical pyrites turn alſo a great quantity of lead into glaſs, on account of the abundance of the arſenic they contain. For which reaſon theſe ores muſt be previouſly roaſted, that the ſulphur and arſenic may be diſſipated. Nor need you fear leſt any part of the ſilver be carried away with the arſenic; for when arſenic is ſeparated from any fixed body, by a certain degree of fire, it carries nothing of that body away with it.”

PROCESS V.

SILVER may be precipitated from its ore by cupellation only, in the following Proceſs, given by Cramer. [*Art of Aſſaying*, *Part* II. *Proc.* 9]

“ Pound one centner of ore; roaſt it in the manner directed in the laſt proceſs; beat it to a moſt ſubtle powder; and if it melts with difficulty on the fire, grind it together with one centner of litharge, which is not neceſſary when the ore melts eaſily: then divide the mixture or the powder of the ore alone into five or ſix parts, and wrap up every one of them ſeverally in ſuch bits of paper as can contain no more than this ſmall portion.

“ Put a very large coppel under the muffle; roaſt it well firſt, and then put into it ſixteen centners of lead: when the lead begins to ſmoak and boil, put upon it one of the ſaid portions with the ſmall paper it was wrapt up in, and diminiſh the fire immediately, in the ſame manner as if you would make a ſcorification in a teſt, but in a leſſer time. The ſmall paper, which turns preſently to aſhes, goes off of itſelf, and does not ſenſibly encreaſe the maſs of the ſcorias. The ore proceeding therefrom is caſt on the border, and turns to ſcorias very ſoon. Increaſe the fire again immediately, and, at the ſame time, put another portion of the ore into the coppel, as was juſt now ſaid. The ſame effects will be produced. Go on in the ſame manner, till all the portions are thrown in and conſumed in the lead. Finally, deſtroy the remaining lead with a ſtronger fire.

“ The ſilver that was in the ore and in the lead will remain in the coppel. If you deduct from it the bead proceeding from the lead, you will have the weight of the ſilver contained in the ore. If the ore employed was eaſy to be melted, all the ſcoria vaniſhes; but if it was refractory or not fuſible, all the ſcoria does not always go away, but there remains ſomething of it now and then in the form of duſt. A great many ores and metals may be tried in this way, except only ſuch as ſplit and corrode the coppels. There are likewiſe ſome of them which muſt be previouſly prepared, in the ſame manner as is required, to render them fit for going through a ſcorification. *See the foregoing Proceſſes.*

“ *Remarks.* The ore thrown at ſeveral times upon lead boiling in a coppel may be diſſolved without the foregoing ſcorification: but this is very far from having an equal ſucceſs with all kinds of ores; for there are ores and metals which reſiſt very much to their diſſolution by litharge; and which being on this account thrown on the border, are not ſufficiently diſſolved; becauſe the litharge ſteals away ſoon into the coppel. Nevertheleſs, there are ſome others which vaniſh entirely by this method, except the ſilver and gold that was contained in them.

“ A previous roaſting is neceſſary, firſt, for the reaſons mentioned, and then becauſe the ore thrown upon boiling lead ſhould not crackle and leap out; for, having once paſſed the fire, it bears the moſt ſudden heat.”

as copper purified by fuſions from the ore (*k*). 2. Copper is found in form of calx, of verdigreaſe, of precipitates. Such are the minerals called ſilky copper ores, and ſeveral white and green earths. Theſe matters are only copper almoſt pure and but little mineraliſed, but which has been corroded, diſſolved, precipitated, calcined by ſaline matters, by the action of the air, of water, and of earths (*l*). 3. Copper is frequently in a truly mineral ſtate, that is,

PROCESS VI.

“ *Silver may be precipitated out of the ſame bodies as were mentioned in the foregoing proceſſes by ſcorification in a crucible.* [*Cramer*, *Proc*. xv.]

“ THE body out of which you intend to precipitate ſilver muſt be previouſly prepared for a ſcorification by pounding and roaſting, as mentioned in the former proceſſes. Then in the ſame manner, and with the ſame quantity of lead, put it into a crucible ſtrictly examined, that it be entire, ſolid, not ſpeckled with black ſpots, like the ſcoria of iron, eſpecially at its inferior parts, and capable of containing three times as much. Add beſides glaſs gall and common ſalt, both very dry, and enough, that when the whole is melted, the ſalts may ſwim at top at the height of about half an inch.

“ Put the crucible thus loaded into a wind-furnace; ſhut it cloſe with a tile; put coals round it, but not higher than the upper border of the crucible. Then light them with burning coals, and increaſe the fire till the whole melts very thin, which will be done by a middling fire, maintained always equal, and never greater: leave it thus for about one quarter of an hour, that the ſcorification may be perfectly made. Take off the tile and ſtir the maſs with an iron wire, and a little after pour it out into the mould. When the regulus is cleaned from ſcorias, try it in a teſt by coppelling it.

“ *Remarks*. The ſcorification of any ore whatever, or of any body fetched out of ores, may indeed be made by this apparatus, as well as in a teſt under a muffle: but it ſerves chiefly to the end that a greater quantity of metal may be melted from it with profit. For you may put many common pounds of it at one ſingle time into the crucible; but then you need not obſerve the proportion of lead preſcribed in the foregoing proceſs; nay, a quantity of lead two or three times leſs is ſufficient, according to the different qualities of the object. But the maſs will certainly be ſpilt, unleſs you chuſe a very good crucible; for there is no veſſel charged with litharge, that can bear a ſtrong fire having a draught of wind, without giving way through it to the litharge.

“ You add glaſs-gall and common ſalt, that they may forward the ſcorification, by ſwimming at top; for the refractory ſcoria rejected by the litharge, and adhering between this and the ſalts, that ſwim at top; is ſoon brought to a flux; and the precipitation of the ſilver is thereby accelerated. They alſo hinder in a manner a ſmall burning coal fallen into the crucible, from ſetting the litharge a boiling, which troubles the operation; for the litharge or glaſs of lead, eſpecially that which is made without any addition, ſo ſoon as the phlogiſton gets into it, raiſes into a foamy maſs, conſiſting of a multitude of ſmall bubbles very difficult to be confined, unleſs the phlogiſton be entirely conſumed, and the litharge reduced to lead, which ſometimes riſes above the border of the veſſel.”

Native metallic ſilver may be ſeparated from the ſtones and earths with which it is intermixed, by *amalgamation with mercury*, which operation is to be performed in the ſame manner as for the ſeparation of native gold; a detail of which ſee at the article SMELTING *of* ORES.

The *corneous ore*, if it really be, as Cronſtedt ſays, a luna cornea, ought to be treated in ſome of the methods directed for the reduction of luna cornea. *See* LUNA CORNEA.

(*k*) COPPER ORES. *Native Copper* is ſolid; or conſiſting of friable maſſes, formed by precipitation of cupreous vitriolic waters, called *cément*, or *ziment copper*; or forming cryſtallized cubes, or grains, leaves, branches, or filaments.

(*l*) *Calciform ores* are either pure calxes of copper, or are mixed with heterogeneous matters. 1. The *pure* are looſe friable ochre, combined with ſulphur, and with arſenic, with other metallic matters mixed with earths, and enveloped in different matrixes. Theſe are the true copper ores. They have no regular forms except they partake of the nature of pyrites Their colors are very different, which depend chiefly on the proportion of the mineral ſubſtances compoſing them. Laſtly, in almoſt all of them we may perceive green or blue colors, which always indicate an eroſion or calcination of the copper. Moſt copper ores contain alſo ſome iron or ferruginous earth, to which the ochrey color is to be attributed, which might make us believe them to be ores of iron. Ores which contain much iron are the moſt difficultly fuſible.

Copper-ores have almoſt all a yellow, golden, and ſhining color, by which they are eaſily diſtinguiſhed. Some of them are colored with iriſes, and frequently have ſpots of verdegriſe, by which alſo they are diſtinguiſhable from other ores. (*m*)

Ores of copper may be *eſſayed* in methods ſimilar to thoſe employed for ſmelting of large quantities of ores (*ſee* SMELTING *of* ORES); or they may in general be eſſayed by the following proceſſes.

PROCESS I.

[Extracted from *Cramer's Art of Aſſaying*, *Proc.* 35.]

“ *To reduce and precipitate copper from a pure*
“ *and fuſible ore in a cloſe veſſel.*”

“ MIX one, or, if you have ſmall weights, two docimaſtical centners of ore beat extremely fine, with ſix centners of the black flux; and having put them into a crucible or pot, cover them one inch high with common ſalt, and preſs them down with your finger: but let the capacity of the veſſel be ſuch, that it may be only half full; ſhut the veſſel cloſe; put it into the furnace; heap coals upon it ſo that it may be covered over with them a few inches high; govern the fire in ſuch a manner, that it may firſt grow ſlightly red-hot. Soon after you will hear your common ſalt crackle; and then there will be a gentle hiſſing noiſe. So long as this laſts, keep the ſame degree of fire till it is quite over. Then encreaſe ſuddenly the fire, either with the funnel and cover put upon the furnace, or with a pair of bellows applied to the hole of the bottom part, that the veſſel may grow very red-hot. Thus you will reduce and precipitate your copper in about a quarter of

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ochre, called *cæruleum montanum*, mountain blue, and *viride montanum*, mountain-green; and the *red indurated calx*, called improperly *glaſs copper ore*. 2. *Mixed* calciform ores are thoſe in which the calx of copper is mixed; with *calcareous earth*, forming a mountain blue; with *iron*, forming a black calx; with *gypſum*, an indurated green ore, called *malachites*; and with *quartz*, a red ore.

(*m*) Copper is *mineraliſed*, 1. By *ſulphur*, forming the *grey copper ore*, improperly called *vitreous* (minera cupri vitrea Wallerii). 2. By *ſulphurated iron*, forming the *hepatic copper ore* (minera cupri hepatica Wallerii) of a brown yellow color. It is a kind of cupreous pyrites, and is called by Cronſtedt minera cupri pyritacea. Sometimes it is of a blackiſh grey color, and is then called *pyrites cupri griſeus* (minera cupri griſea Wallerii); ſometimes of a reddiſh yellow, and tarniſhed with blue iriſes on its ſurface, when it is called *minera cupri lazurea*; when of a yellowiſh-green color, it is the *pyrites cupri flavo virideſcens* (cuprum ſulphure & ferro mineraliſatum Wallerii); and when of a pale-yellow color, it is the *pyrites cupri pallide flavus.* Moſt of the above pyritaceous ores contain alſo ſome arſenic, but their ſulphur is predominant. 3. *Copper mineraliſed by ſulphur, iron, and arſenic. White copper-ore* (Minera cupri alba Wall.). This ore contains alſo ſome ſilver. 4. *Copper diſſolved by vitriolic acid. Native blue vitriol.* 5. *Copper united with bitumens. Copper coal-ore.* This is a pitcoal from the aſhes of which copper is obtainable. 6. Copper is alſo found in the mineral called *kupfer-nickel.*

Many copper ores are alſo rich in ſilver. Such is that called the white copper ore, the color of which is rather occaſioned by arſenic than by ſilver, al-

“ of an hour: then take out the veſſel, and ſtrike with a few blows the pavement upon which you put it, that all the ſmall grains of copper may be collected in one maſs.

“ Break the veſſel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole proceſs has been well performed, you will find a ſolid, perfectly yellow and malleable regulus adhering to the bottom of the veſſel, with ſcorias remaining at top of a brown color, ſolid, hard, and ſhining, from which the regulus muſt be ſeparated with ſeveral gentle blows of a hammer; this done, weigh it, after having wiped off all the filthineſs.

“ A ſoft duſty and very black ſcoria is a ſign of a fire not ſufficiently ſtrong. Small neat grains of copper reduced but not precipitated, and adhering ſtill to ſcorias, eſpecially not very far from the bottom, and an unequal and ramificated regulus, are ſigns of the ſame thing. A ſolid, hard, ſhining, red-colored ſcoria, eſpecially about the regulus, or even the regulus itſelf when covered with a like ſmall cruſt, are ſigns of an exceſs in the degree and duration of the fire.

“ *Remarks.* All the ores which are eaſily melted in the fire are not the objects of this proceſs; for they muſt alſo be very pure. Such are the vitreous copper ores.” [Mr. Cramer means, I preſume, the red calciform ore called improperly *glaſs ore*, and not the *minera cupri vitrea* of Wallerius, which being compoſed of copper mineraliſed by ſulphur, could not be treated properly by this proceſs, in which no previous roaſting is required. The ſulphur of this ore would with the alkali of the black flux form a hepar, from which the metal would not precipitate,] “ but eſpecially the green and azure-colored ores, and the cæruleum & viride montanum, which are not very different from them. But if there is a great quantity of arſenic, ſulphur, or of the ore of another metal and ſemi-metal joined to the ore of copper, then you will never obtain a malleable regulus of pure copper, tho' ores are not always rendered refractory by the preſence of theſe.”

PROCESS II.

[*Cramer Pr.* xxxvii.]

“ *To reduce and precipitate copper out of ores rendered refractory by earth and ſtones that cannot be waſhed off.*

“ BEAT your ore into a moſt ſubtil powder, of which weigh one or two centners, and mix as much ſandiver to them. This done, add four times as much of the black flux with reſpect to the ore; for by this means, the ſterile terreſtrial parts are better diſpoſed to a ſcorification, and the reducing and precipitating flux may act more freely upon the metallic particles freed from all their incumbrances.

“ As for the reſt, make the apparatus as in laſt proceſs: but you muſt make the fire a little ſtronger for about half an hour together. When the veſſel is grown cold and broken, examine the ſcorias, whether they are as they ought to be. The regulus will be as fine and ductile as the foregoing.

“ *Remarks.* As theſe copper-ores hardly conceal any ſulphur and arſenic in them, the roaſting would be of no effect, and much copper would be loſt. For no metallic calx, except thoſe of gold and ſilver, improperly ſo called, can be roaſted, without you find a part of the metal loſt after the reduction.”

PROCESS III.

“ *To precipitate copper out of an ore* * *that contains iron.* [*Cramer Proc.* xxxviii.]

“ DO all according to laſt proceſs. But you will find after the veſſel is broken, a regulus upon no account ſo fine, but leſs ductile, wherein the genuine color of the copper does not perfectly appear, and which muſt be further purified.

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* Mr. Cramer ſtill means the calciform ores only, and not the mineraliſed ores of copper.

though it contains ſo much ſilver as to be enumerated by ſeveral mineralogiſts amongſt ſilver ores.

“ *Remarks.* The fire uſed in this operation is not ſo ſtrong that the iron ſhould turn to a regulus. But as copper is the menſtruum of iron, which is of itſelf very refractory in the fire; for this reaſon, while the ore and the flux are moſt intimately mixt and confounded by trituration, the greateſt part of the iron being diſſolved by the copper, turns into a regulus along with it.”

PROCESS IV.

[*Cramer Proc.* xxxix.]

“ *The roaſting of a pyritoſe, ſulphureous, arſenical, ſemi-metallic copper ore.*

“ BREAK two docimaſtical centners of the ore to a coarſe powder, put them into a teſt covered with a tile, and place them under the muffle of a docimaſtical furnace. But the fire muſt be ſo gentle, that the muffle may be but faintly red-hot. When the ore has decrepitated, open the teſt, and continue the fire for a few minutes; then increaſe it by degrees, that you may ſee the ore perpetually ſmoaking a little: in the mean time, it is alſo proper now and then to ſtir it up with an iron hook. The ſhining particles will aſſume a dark red or blackiſh color. This done, take out the teſt, that it may grow cold. If the ſmall grains are not melted, nor ſtrongly adherent to each other, hitherto all will be well; but if they run again into one ſingle cake, the proceſs muſt be made again with another portion of the ore, in a more gentle fire.

“ When the ore is grown cold, beat it to a powder ſomewhat finer, and roaſt it by the ſame method as before; then take it out, and if the powder is not melted yet, beat it again to a moſt ſubtil powder; in this you are to take care that nothing be loſt.

“ Roaſt the powder in a fire ſomewhat ſtronger, but for a few minutes only. If you do not then find the ore any way inclined to melt, add a little tallow, and burn it away under the muffle, and do the ſame another time again, till the fire being very bright, you no longer perceive any ſulphureous, arſenical, unpleaſant ſmell, or any ſmoak; and there remains nothing but a thin, ſoft powder, of a dark red, or blackiſh color.

“ *Remarks.* Every pyrites contains iron, with an unmetallic earth: to which ſulphur, or arſenic, and moſt commonly both always join. Beſides, there is copper in many pyrites; but ſometimes more, and ſometimes leſs: ſome of them are altogether deſtitute of copper; therefore, ſo much as pyrites differ with regard to the proportion of their conſtituent particles, ſo much do they differ as to their diſpoſition in the fire. For inſtance, the more copper there is in pyrites, the more it inclines to colliquation. The more ſulphur and arſenic it has in it, the more quickly the melting of it will be procured, and the reverſe: the more iron and unmetallic earth it contains, the more it proves refractory in the fire. Now if ſuch pyrites melt in the roaſting; as happens to ſome of them, if they grow but red-hot; the ſulphur and arſenic that lies hidden therein are ſo ſtrictly united with the fixed part, that you would in vain attempt to diſſipate them. Nay, in this caſe, when it is reduced again into a powder, it requires a much greater time and accuracy in the regimen of the fire to perform the operation. For this reaſon, it is much better to repeat it with new pyrites. But you can roaſt no more than the double quantity at once of the ore you have a mind to employ in the foregoing experiment; to the end that, the precipitation by fuſion not ſucceeding, there may remain ſtill another portion entire; leſt you ſhould be obliged to repeat a tedious roaſting. If you ſee the ſigns of a ferreous refractory pyrites, the operation muſt be performed with a greater fire, and much more quickly. However, take care not to do it with too violent a fire: for a great deal of copper is conſumed not only by the arſenic, but alſo by the ſulphur; and this happens even in veſſels ſhut very cloſe, when the ſulphur is expelled by a fire not quite ſo ſtrong; which a reiterated and milder ſublimation of the ſul-

Laſtly, the pyrites of a golden-yellow color which contains copper and ſulphur, and the white pyrites which contains copper and arſenic, are conſidered

phur in a veſſel both very clean and well cloſed, will clearly ſhew.

“ When the greateſt part of the ſulphur and the arſenic is diſſipated, by ſuch cauſes as promote colliquation you may make a ſtronger fire: but then it is proper to add a little of ſome fat body; for this diſſolves mineral ſulphur; it changes the mixture of it in ſome part, which, for inſtance, conſiſts in a certain proportion of acid and phlogiſton, and at the ſame time hinders the metallic earth from being reduced into copper, by being burnt to an exceſs. From theſe effects the reaſon is plain, why aſſayers produce leſs metals in the trying of veins of copper, lead, and tin, than ſkilful ſmelters do in large operations. For the former perform the roaſting under a muffle, with a clear fire, and without an oily reducing menſtruum; whereas the latter perform it in the middle of charcoal or of wood, which perpetually emit a reductive phlogiſton.

“ The darker and blacker the powder of the roaſted ore appears, the more copper you may expect from it. But the redder it looks, the leſs copper and the more iron it affords; for roaſted copper diſſolved by ſulphur or the acid of it is very black, and iron, on the contrary, very red.

“ It is eaſy to conceive, that there is as great a difference between the ſeveral kinds of that metal called black copper, as there is between the pyritoſe and other copper-ores, accidentally mixed with other metallic and ſemi-metallic bodies. For all the metals, the ores of which are intermixed with the copper-ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Wherefore iron, lead, tin, the reguline part of antimony, biſmuth, moſt commonly are mixed with black copper in a multitude of different proportions. Nay it is ſelf-evident, that gold and ſilver, which are diſſolvable by all theſe matters, are collected in ſuch a regulus, when they have been firſt hidden in the ore. Beſides, ſulphur and arſenic are not always altogether abſent. For they can hardly be expelled ſo perfectly by the many preceding roaſtings, but there remain ſome veſtiges of them, which are not diſſipated by a ſudden melting, eſpecially in a cloſe veſſel, wherein the flux ſwimming at top hinders the action of the air. Nay arſenic is rather fixed by the black flux, and aſſumes a reguline ſemi-metallic form, while it is at the ſame time preſerved from diſſipating by the copper.

PROCESS V.

[*Cramer Pr.* xl.]

“ *The precipitation of copper out of roaſted ore of the laſt proceſs.*

“ DIVIDE the roaſted ore into two parts: each of them ſhall go for a centner: add to it the ſame weight of ſandiver, and four times as much of the black flux, and mix them well together. As for the reſt, do all according to the proceſs I.* The precipitated regulus will be half malleable, ſometimes quite brittle, now and then pretty much like pure copper in its color, but ſometimes whitiſh, and even blackiſh. Whence it is moſt commonly called *black copper*, though it is not always of ſo dark a dye.

PROCESS VI.

[*Cramer, Proc.* xliv.]

“ *To reduce black copper into pure copper by ſcorification.*

“ SEPARATE a ſpecimen of your black copper, of the weight of two ſmall docimaſtical centners at leaſt; and do it in the ſame manner, and with the ſame precautions, as if you would detect a quantity of ſilver in black copper.

“ Then with lute and coal-duſt make a bed in the cavity of a teſt moiſtened: when this bed is dry, put it under the muffle of the docimaſtical furnace, in the open orifice of which there muſt be bright burning coals, wherewith the teſt muſt likewiſe be ſurrounded on all parts. When as copper ores by ſeveral chemiſts and naturaliſts, *See* **Pyrites.** Henckel and Cramer remark, that no proper ore of copper is known which does not contain a conſiderable quantity of arſenic.

DXIV. ORES *of* LEAD. Lead is ſeldom found native and malleable. Neither is it found in form of calx or precipitate, as copper is,

“ the whole is perfectly red-hot, put your copper into the fire, alone, if it contains lead; but if it is altogether deſtitute of it, add a ſmall quantity of glaſs of lead, and with a pair of hand-bellows increaſe the fire, that the whole may melt with all ſpeed: this done, let the fire be made a little leſs violent, and ſuch as will ſuffice to keep the metallic maſs well melted; and not much greater. The melted maſs will boil, and ſcorias will be produced, that will gather at the circumference. All the heterogeneous matters being at laſt partly diſſipated, and partly turned to ſcorias, the ſurface of the pure melted copper will appear. So ſoon as you ſee it, take the pot out of the fire, and extinguiſh it in water: then examine it in a ballance, and if lead has been at firſt mixt with your black-copper, add to the regulus remaining of the pure copper, one fifteenth part of its weight which the copper has loſt by means of the lead, then break it with a vice; and thus you will be able to judge by its color and malleability, and by the ſurface of it after it is broken, whether the purifying of it has been well performed, or no. But whatever caution you may uſe in the performing of this proceſs, the product will nevertheleſs be always leſs in proportion than what you can get by a greater operation, provided the copper be well purified in the ſmall trial.

“ *Remarks.* This is the laſt purifying of copper, whereby the ſeparation of the heterogeneous bodies begun in the foregoing proceſs is completed as perfectly as it poſſibly can be. For, except gold and ſilver, all the other metals and ſemi-metals are partly diſſipated and partly burnt, together with the ſulphur and arſenic. For in the fuſion they either turn of themſelves to ſcoria or fumes, or this is performed by means of iron, which chiefly abſorbs ſemi-metals, ſulphur and arſenic, and the deſtruction of it is at the ſame time accelerated by them. Thus the copper is precipitated out of them pure; for it is ſelf-evident, that the unmetallic earth is expelled, the copper being reduced from a vitreſcent terreſtrial to a metallic ſtate; and the arſenic being diſſipated, by means of which the ſaid earth has been joined to the coarſer regulus's of the firſt fuſion. But there is at the ſame time a good quantity of the copper that gets into the ſcorias: however, a great part of it may be reduced out of them by repeating the fuſion.

“ The fire in this proceſs muſt be applied with all imaginable ſpeed, to make it ſoon run: for if you neglect this, much of your copper is burnt: becauſe copper that is only red-hot, cleaves much ſooner, and in much greater quantity, into half ſcorified ſcales, than it is diminiſhed in the ſame time when melted. However, too impetuous a fire, and one much greater than is neceſſary for the fuſion of it, deſtroys a much greater quantity of it, than a fire ſufficient only to put it in fuſion would do. For this reaſon, when the purifying is finiſhed, the body melted muſt be extinguiſhed in water together with the veſſel, leſt being already grown hard, it ſhould ſtill remain hot for a while; which muſt be done very carefully to prevent dangerous exploſions.

“ The ſcoria of the above proceſs frequently contains copper. To extract which, let two or three docimaſtical centners of the ſcoria, if it be charged with ſulphur, be beat to a ſubtil powder, and mix it, either alone, or, if its refractory nature requires it, with ſome very fuſible, common, pounded glaſs without a reducing ſaline flux, and melt it in a cloſe veſſel, and in a fire having a draught of air; by which you will obtain a regulus.

“ But when the ſcoria has little or no ſulphur at all in it, take one centner of it, and with the black flux, manage it as you do the fuſible copper ore; [Proceſs I.] by which you will have a pure regulus.”

becauſe it is much leſs liable to loſe its phlogiſton by the action of air and water: therefore almoſt all lead is found naturally mineraliſed.

PROCESS VII.

[The following Proceſs is tranſlated from Mr. Gellert's *Elements of Eſſaying*, and deſcribes a new method of eſſaying ores, concerning which, ſee a note (*n*) ſubjoined to the article of this Dictionary ESSAY *of* ORES.]

To eſſay Copper-ores.

ROAST a quintal of ore [in the manner deſcribed in Proceſs IV.]; add to it an equal quantity of borax, half a quintal of fuſible glaſs, and a quarter of a quintal of pitch: put the mixture in a crucible, the inner ſurface of which has been previouſly rubbed with a fluid paſte of charcoal-duſt and water: cover the whole with pounded glaſs mixed with a little borax, or with decrepitated ſea-ſalt: put a lid on the crucible, which you will place in an air-furnace, or in a blaſt-furnace: when the fire ſhall have extended to the bottom of the coals, let it be excited briſkly during half an hour, that the crucible may be of a briſk red color: then withdraw the crucible; and when it is cold, break it: obſerve if the ſcoria be well made: ſeparate the regulus, which ought to be ſemi-ductile; and weigh it. This regulus is *black copper*, which muſt be purified, as in Pr. VI.

If the ore be very poor, and inveloped in much earthy and ſtony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, muſt be added. The calx of lead will be revived, and will unite with the ſcattered particles of the copper, and together with theſe will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glaſs will be ſufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwiſe the large quantity of antimony might deſtroy the copper, eſpecially if the ore contained no lead. If iron be contained in topper-ore, as in pyrites, ſome pounds of antimony, or of its regulus, may be added in the eſſay; as theſe ſubſtances more readily unite with iron than with copper, and therefore diſengage the latter metal from the former.

PROCESS VIII.

To eſſay Ores of Copper by humid Solution.

SOME pyrites and ores contain ſo ſmall a quantity of copper, that it cannot be ſeparated by the above proceſſes, but is deſtroyed by the repeated roaſtings and fuſions. Theſe, and indeed any copper-ores, may be eſſayed by humid ſolution, or by menſtruums.

1. By roaſting a ſulphureous ore, the ſulphur is burnt or decompoſed, its phlogiſton, with part of the acid evaporating, while the remaining part of the acid combines with the metals, eſpecially with the copper and the iron contained in the ore. Accordingly, from an ore thus roaſted, a vitriolic ſolution may be obtained by lixiviation with warm water, eſpecially if the ore has been expoſed, during a few days after it has been roaſted, to a moiſt air; as the water thus gradually applied better unites with the combination of the metallic calxes with the concentrated vitriolic acid of the ſulphur: but all the copper is not thus reduced by one operation to a vitriol. More ſulphur muſt therefore be combined with the reſiduous ore by fuſion, and muſt be again burnt off; that the remaining part of the copper may be attacked by ſome of the acid of the ſulphur. By repeating this operation, almoſt all the copper and iron will be reduced to a vitriolic lixivium, from which the copper may be ſeparated and precipitated by adding clean pieces of iron.

2. Copper-ores may be more eaſily eſſayed by humid ſolution, in the following manner:

Roaſt the mineraliſed ores in the manner directed in Proceſs IV. and pulveriſe them. If the ores be calciform, they do not require a previous roaſting. Put this powder into a matraſs capable of containing ten times the quantity of the ore: pour upon the ore ſome water: ſet the matraſs in a ſand-bath, that

Lead is generally mineraliſed by ſulphur. Its ores have a dark white, but a ſhining metallic color. Theſe ores, although they form irregular maſſes, are internally regularly diſpoſed, and ſeem to be compoſed of cubes of different ſizes applied to each other, but not adherent. Theſe ores are generally diſtinguiſhed by the name *Galena*. They commonly contain about three quarters of lead and a quarter of ſulphur. They are accordingly heavy and fuſible, although much leſs ſo than pure lead.

Moſt lead-ores contain ſilver, none but thoſe of Willach in Carinthia are known to be quite free from it: ſome of them contain ſo much of it, that they are conſidered as improper ores of ſilver. The ſmaller the cubes of galena are, the larger quantity of ſilver has been remarked to be generally contained. (*n*)

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the water may boil: pour off the lixivium: add to the reſiduous ore more water with ſome vitriolic or marine acid: digeſt as before in the ſand-bath, and add this lixivium to the former: repeat this operation, till you find that the acid liquor diſſolves no more metal.

By adding clean plates of iron, you may precipitate the copper, which ought then to be collected, fuſed with a little borax and charcoal duſt, and weighed.

We may remark, that although copper is not ſoluble by a dilute vitriolic acid, yet the calx of it obtained by roaſting the ore, and alſo the calciform ores, are readily ſoluble in that acid.

3. Stahl adviſes to eſſay copper-ores by boiling them, after they have been roaſted and powdered, in water, together with tartar and common ſalt, or with alum and common ſalt: but I have not found this method ſo effectual as the preceding (2).

(*n*) Lead-Ores. Cronſtedt doubts whether any native lead has been found. Linnæus ſays, he has ſeen what externally appeared to be ſuch. The Author of the Dictionary is miſtaken when he ſays, that no calx of lead is found. As lead unites ſtrongly with vitriolic acid, we might expect to meet ochres of this metal as well as of copper. Accordingly, we find ſome *calciform ores* of lead. 1. A pure calx of lead, in form of a friable ochre, *ceruſſa nativa*, found on the ſurface of galena; or it is indurated with a radiated or fibrous texture, of a white or yellowiſh-green color, and reſembling ſpar; it is called *ſpatum plumbi*, *ſparry lead-ore*, and *lead-ſpar*. 2. A calx of lead is found mixed with calx of arſenic, forming the ore called *arſenicated lead-ſpar*. Sometimes alſo that calx is mixed with calcareous earth.

Lead is mineraliſed, 1. With *ſulphur*; ſuch are the ſeveral kinds of ſteel-grained and teſſelated *galenas*, which alſo contain generally ſome ſilver. 2. With *ſulphurated iron and ſilver*. It is fine-grained or teſſelated, and is diſtinguiſhable from the former by yielding a black ſlag when ſcorified, whereas the former yields a yellow ſlag. 3. With *ſulphurated antimony and ſilver*. *Plumbum ſtibiatum Linnæi*. Its color is ſimilar to that of galena, and its texture is ſtriated. 4. With *ſulphur and arſenic*. This ore is ſoft, almoſt malleable, like lead. From this ore lead may be melted by the flame of a candle.

Lead-ores may be eſſayed by means of the black flux, in the manner directed by Mr. Cramer, and deſcribed in the Dictionary at the article Essay *of* Ores; or by the following proceſs of Mr. Gellert.

Mix a quintal of roaſted lead-ore with a quintal of calcined borax, half a quintal of glaſs finely pulveriſed, a quarter of a quintal of pitch, and as much of clean iron-filings: put this mixture into a crucible wetted with charcoal-duſt and water: place the crucible before the nozzle of the bellows of a forge, and when it is red, raiſe the fire during fifteen or twenty minutes; then withdraw the crucible, and break it when cold.

Some very fuſible ores, ſuch as the galena of Derbyſhire, may be eſſayed, as large quantities of it are ſmelted, without previous roaſting, and without addition, merely by fuſion during a certain time. For this purpoſe nothing more is requiſite than to keep the ore melted in a crucible with a moderate heat, till all the ſulphur is deſtroyed, and the metal be collected. To prevent the deſtruction of any part of the metal after it is ſeparated from the ſulphur, ſome charcoal duſt may

DXV. TIN-ORES. Tin is very ſeldom found pure, but almoſt always mineraliſed, and chiefly by arſenic.

The richeſt ore of arſenic is of an irregular form, of a black or tarniſhed color, and almoſt the heavieſt of all ores. The cauſe of this extraordinary weight is, that it contains much more arſenic than ſulphur, whereas moſt ores contain more ſulphur than arſenic.

The moſt common tin-ore is of the color of ruſt, which proceeds from a quantity of iron, or of iron-ore mixed with it. The tin-ores of Saxony and Bohemia appear to be all of this kind.

One kind of tin-ore is ſemi-tranſparent and like ſpar. Laſtly, ſeveral kinds of garnets are enumerated by mineralogiſts amongſt tin-ores, becauſe they actually contain tin.

The county of Cornwall, in England, is very rich in tin-ores, and the tin contained in them is very pure. From tin-mines in the Eaſt-Indies tin is brought, called *Malacca tin.* No mines of tin have been diſcovered in France; only in Bretagne garnets are found which contain ſome tin. *(o)*

DXVI. ORES *of* IRON. No iron is found in its metallic ſtate, although ſeveral ſands and earths have the appearance of iron, and are even attractable by a magnet.

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may be thrown over the ore, when put into the crucible: but if the galena be mixed with pyrites, eſpecially arſenical pyrites, it requires much roaſting and ſaline fluxes.

(*o*) TIN-ORES. *Native tin* is ſaid to have been found in Saxony and Malacca. Its ores are all of the calciform kind, excepting *black-lead*, which appears to be tin *mineraliſed by ſulphur and iron.* *See* MOLYBDENA.

The *calciform ores* of tin are, 1. *Tin-ſtone*, which is of a blackiſh-brown color, and of no determinate figure; and *tin-grains*, or *cryſtals of tin*, which reſemble garnets, and are of a ſpherical or polygonal figure, which they have probably acquired by the attrition of their angles. The tin-ſtone ſeems to conſiſt of attrited tin-grains. This ore is calx of tin united with calx of arſenic, and frequently with calx of iron. 2. *Garnets* are ſaid to contain calx of tin united with calx of iron. 3. *Manganeſe* is ſaid alſo to contain tin. *See* MANGANESE.

Ores of tin may be eſſayed in the ſame manner, according to Cramer, as he directed for the eſſay of lead-ores. *See* ESSAY *of* ORES. He further makes upon this eſſay the following remarks.

1. Tin-ore, on account of its greater gravity, admits better of being ſeparated, by elutriation or waſhing, from earths, ſtones and lighter ores. 2. A moſt exact ſeparation of earths and ſtones ought to be made, becauſe the ſcorification of theſe by fluxes requires ſuch a heat as would deſtroy the reduced tin. 3. The iron ought to be ſeparated by a magnet. 4. By a previous roaſting, the arſenic is diſſipated, which would otherwiſe carry off a great deal of tin along with it in a melting heat, would change another part of it into aſhes, and would vitiate the remaining tin. 5. The eſſay of tin is very precarious and uncertain; becauſe tin once reduced is eaſily deſtructible by the fire, and by the ſaline fluxes requiſite for the reduction.

Mr. Gellert directs, that ores of tin ſhould be eſſayed in the following manner:

Mix a quintal of tin-ore, waſhed, pulveriſed, and twice roaſted, with half a quintal of calcined borax, and half a quintal of pulveriſed pitch: theſe are to be put into a crucible moiſtened with charcoal-duſt and water, and the crucible placed in an air-furnace: after the pitch is burnt, give a violent fire during a quarter of an hour; and then withdraw your crucible. If the ore be not very well waſhed from the earthy matters, as it ought to be, a larger quantity of borax is requiſite, with ſome powdered glaſs, by which the too quick fuſion of the borax is retarded, and the precipitation of the earthy matters is prevented. If the ore contains iron, to the above mixture may be added ſome alkaline ſalt.

Neither is iron generally mineraliſed ſo diſtinctly as other metals are, unleſs in pyrites and ores of other metals.

Moſt of the minerals called iron-ores have an earthy, ruſty, yellowiſh or browniſh appearance, which proceeds from the facility with which the true iron-ores are decompoſed.

Iron is the moſt common and moſt abundant of all metals. In Europe, at leaſt, we cannot find an earth, a ſand, a chalk, a clay, a vitrifiable or calcinable ſtone, or even the aſhes of any ſubſtance, which do not contain an earth convertible into iron. All earths and ſtones which are naturally yellow or red, and all thoſe which acquire theſe colors by calcination, receive them from the ferruginous earth mixed with them. The yellow and red ochres conſiſt almoſt ſolely of this earth: the black and heavy ſands are generally very ferruginous.

One of the richeſt iron-ores is a heavy ſtone, the ſurface of which, when newly broken, is red and bluiſh, and is exceedingly hard. A quintal of this ore furniſhes from ſixty to eighty pounds of the beſt iron by a ſingle fuſion, according to Mr. Cramer.

The iron-ore moſt commonly found is a ſtone of the color of ruſt, of an intermediate weight betwixt thoſe of ores in general and of unmetallic ſtones. This ore has no determinate form, and eaſily furniſhes an iron of good quality.

Blood-ſtone or hematites, ſanguine or red-chalk, and emery, are iron-ores; ſome of which, for inſtance, blood-ſtone, are almoſt all iron. Moſt of theſe ſubſtances require but a ſlight calcination to be rendered very attractable by a magnet, and ſoluble in aqua fortis: but the iron obtained from them is of a bad quality, and they are therefore neglected. Iron from the hematites is very brittle; that obtained from ochres is red-ſhort. All theſe iron-ores are ſo refractory, that they can ſcarcely be fuſed.

Iron-ores are very various in their form; or rather they have no determinate form. Sometimes they are earths, ſometimes ſtones, ſometimes grains. Accordingly, thoſe naturaliſts who attend only to the external form of things in claſſing and ſubdividing minerals, have been obliged to multiply the names of iron-ores: hence they are called *iron-ores in form of peaſe*, *of beans*, *of coriander ſeeds*, *of pepper-corns*, *of cinnamon*, &c. which Mr. Cramer treats as ridiculous trifles. (*p*)

(*p*) ORES *of* IRON. I. Malleable *native iron* is mentioned by Wallerius, Linnæus, and Cartheuſer. II. The *calciform ores* of iron are pure, or mixed. The *pure* calciform ores are, 1. Friable, as the *martial ochre*, which is either in powder, or concreted, as the *bog-ore*; or, 2. they are indurated, *Hematites*. *See* HEMATITES. The *mixed* calciform ores conſiſt of the calx of iron mixed with heterogeneous ſubſtances: 1. With *calcareous earth*; forming the *white ſpathoſe* iron ore. 2. With *ſiliceous earth*, forming *martial jaſper*. 3. With *garnet-earth*, forming *garnets* and *baſaltes*. 4. With *argillaceous earths*, forming *boles*. 5. With *micaceous earth*, forming *colored micas*. 6. With *manganeſe*. *See* MANGANESE. 7. With an *unknown earth*, which hardens like cement in water; *Terras*. This is chiefly found in the neighbourhood of volcanos. III. Iron is *mineraliſed*, 1. With *ſulphur*, forming *martial pyrites*; *black iron-ore*, which is magnetic, the quantity of ſulphur being very ſmall; the *load-ſtone*. With *arſenic*; *white pyrites*. 3. With *ſulphur and arſenic*; the *arſenical pyrites*. 4. With *vitriolic acid*; *native martial vitriol*. 5. With *phlogiſton*; *martial coal-ore*. 6. With other ſulphurated and arſenicated metals.

Ores of iron may be eſſayed by the following Proceſſes.

DXVII. ORES *of* MERCURY. Mercury is ſometimes found pure, fluid, and in its proper metallic ſtate, only mixed with earths and ſtones. Such are the ores of mercury found near Montpellier, in Tuſcany, and in other places.

PROCESS I.

[CRAMER's *Art of Eſſaying*, *Proceſs* 54.]

To reduce a precipitate Iron out of its Ore in a cloſe Veſſel.

" ROAST for a few minutes in a teſt " under a muffle, and with a pretty ſtrong " fire, two centners of the ſmall weight of " your iron ore groſsly pulveriſed; that the " volatiles may be diſſipated in part, and the " ore itſelf be ſoftened in caſe it ſhould be " too hard. When it is grown cold, beat " it extremely fine, and roaſt it a ſecond " time, as you do the copper-ore, but in a " much ſtronger fire, till it no longer emits " any ſmell; then let it grow cold again. " Compoſe a flux of three parts of the white " flux, with one part of fuſible pulveriſed " glaſs, or of the like ſterile unſulphureous " ſcorias, and add ſandiver and coal-duſt, of " each one half-part; add of this flux three " times the quantity of your roaſted ore, " and mix the whole very well together; " then chuſe a very good crucible, well " rubbed with lute within, to ſtop the pores " which may be here and there unſeen; put " into it the ore mixed with the flux; cover " it over with common ſalt; and ſhut it cloſe " with a tile and with lute applied to the " points.

" Put the wind-furnace upon its bottom " part, having a bed made of coal-duſt. [*See* " *Plate* III.] Introduce beſides into the fur- " nace a ſmall grate ſupported on its iron " bars, and a ſtone upon it; whereon the " crucible may ſtand as on a ſupport: ſur- " round the whole with hard coals, not " very large, and light them at top; when " the veſſel begins to grow red, which is " indicated by the common ſalt's ceaſing to " crackle, ſtop with groſs lute the holes of " the bottom part, except that in which the " nozzle of the bellows is received: blow " the fire, and excite it with great force, " adding now and then freſh fuel, that the " veſſel may never be naked at top: having " thus continued your fire in its full ſtrength " for three quarters of an hour, or for a " whole hour, take next the veſſel out of it, " and ſtrike ſeveral times the pavement upon " which it is ſet, that the ſmall grains of " iron which happen to be diſperſed may " be collected into a regulus, which you " will find after having broken the veſſel.

" When the regulus is weighed, try its " malleability; then make it red-hot; and " when ſo, ſtrike it with a hammer: if it " bears the ſtrokes of a hammer, both when " red-hot and when cold, and extends a " little, you may pronounce your iron very " good: but if, when either hot or cold, it " proves brittle, you may judge it to be not " quite pure, but ſtill in a ſemi mineral " condition.

" *Remarks.* The arſenic, but eſpecially " the ſulphur, muſt be diſſipated by roaſting; " for the former renders the iron brittle, and " the latter not only does the ſame, but, be- " ing managed in a cloſe veſſel, with a ſaline " alkaline flux, turns to liver of ſulphur; to " the action of which iron yielding in every " reſpect, it can upon no account be preci- " pitated; and if not the whole, a great part " of it, at leaſt, is retained by the ſulphu- " reous ſcoria; ſo that in this caſe you com- " monly in vain look for a regulus.

" The iron obtained from this firſt preci- " pitation has hardly ever the requiſite duc- " tility, but is rather brittle: the reaſon of " which is, that the ſulphur and arſenic re- " main in it; for notwithſtanding that the " greateſt part of theſe is diſſipated by roaſt- " ing, yet ſome part adheres ſo ſtrictly, that " it can never be ſeparated but with abſor- " bent, terreſtrial, alkaline ingredients, that " change the nature of the ſulphur. For " which reaſon, in larger operations, they " add quicklime, or marble-ſtones that turn " into quicklime; which, while they abſorb " the ſaid minerals, are, by it, and by help " of the deſtroyed part of the iron, brought " to a fuſion, and turn to a vitrified ſcoria; " although, at other times, they reſiſt ſo " much by their own nature a vitrification. " Another cauſe of the brittleneſs of iron is

But the largeſt quantity of the mercury found in the earth is mineraliſed by ſulphur, and conſequently is in the form of cinnabar. *See* Cinnabar.

“ the unmetallic earth, when it is not yet
“ ſeparated from it; for the iron-ore con-
“ tains a great quantity of it, and in the
“ melting remains joined with the reguline
“ part: whence the iron is rendered very
“ coarſe and brittle. Some iron-ores are al-
“ together untractable: nevertheleſs, the
“ reguluſſes produced out of them, when
“ broken, have ſometimes a neat ſemime-
“ tallic look; which proceeds undoubtedly
“ from a mixture of a ſmall quantity of ſome
“ other metal or ſemimetals.

PROCESS II.

[The following Proceſs for eſſaying iron-ores, and ferruginous ſtones and earths, is extracted from Mr. Gellert's *Elements of Eſſaying*.]

ROAST two quintals of iron-ore, or of ferruginous earth: divide the roaſted matter into two equal parts; to each of which add half a quintal of pulveriſed glaſs, if the ſubſtance be fuſible, and contains much metal; but if otherwiſe, add alſo half a quintal of calcined borax. If the roaſting has entirely diſengaged the ſulphur and arſenic, an eighth part, or even half a quintal, of quicklime may be added. With the above matters, mix twelve pounds of charcoal powder.

Take a good crucible, and cover the bottom and ſides of its inner ſurface with a paſte made of three parts of charcoal-duſt and one part of clay beat together. In the hollow left in this paſte put the above mixture; preſs it lightly down; cover it with pulveriſed glaſs; and put on the lid of the crucible.

Place two ſuch crucibles at the diſtance of about four fingers from the air-pipe, in ſuch a manner that the air ſhall paſs betwixt them at about the third part of the height from the bottom: fill the ſpace betwixt the two crucibles with coals of a moderate ſize: throw lighted coals upon them, that the fire may deſcend and make them red-hot from top to bottom: at firſt let the bellows blow ſoftly, and afterwards ſtrongly during an hour, or an hour and a quarter: then take away the crucible, and break it when cold. A regulus will be found in the bottom, and ſometimes ſome ſmall grains of iron in the ſcoria, which muſt be ſeparated and weighed along with the regulus: then try the regulus, whether it can be extended under the hammer, when hot and when cold.

Remarks. To diſengage a metal from the earthy matters mixed with it by fire, we muſt change theſe matters into ſcoria or glaſs. This change may be effected by adding ſome ſubſtance capable of diſſolving theſe matters; that is, of converting them into a ſcoria or glaſs, from which the metallic matters may, by their weight, ſeparate and form a regulus at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful ſolvent of earths and ſtones: but the alkali does alſo diſſolve iron, eſpecially when this is in a calcined or earthy ſtate; and this ſolution is ſo much more compleat, as the fire is longer applied. Hence, in ordinary eſſays, where an alkaline ſalt is uſed, little or no regulus of iron is obtained. Now, glaſs acts upon, and diſſolves earths and ſtones; but not, or very little, iron: conſequently glaſs is the beſt flux for ſuch eſſays: and experience confirms this aſſertion. If the ore contains but little iron, we may alſo add to the glaſs ſome borax; but borax cannot be employed ſingly, becauſe it very ſoon fuſes, and ſeparates from the ore before the metal is revived. Quicklime is added, not only to abſorb the ſulphur and arſenic remaining in the ore, but alſo becauſe it diſſolves and vitrifies the ſtony and earthy matters of iron-ores, which are generally argillaceous. For which reaſon, in the large operations for ſmelting iron-ore, quicklime and even in certain caſes gypſum are commonly added to facilitate the fuſion.

The reduction of iron-ore, and even the fuſion of iron, requires a violent and long-continued heat: therefore, in this operation, we muſt not employ an inflammable ſubſtance, as pitch, that is ſoon conſumed, but charcoal pulveriſed, which in cloſe veſſels is not ſenſibly waſted. Too much charcoal muſt not be added, elſe it will prevent the action of the glaſs upon the earthy matter of the ore, and conſequently the ſeparation of the metallic part. Experiments have taught me, Mercury is never mineraliſed by arſenic. The richeſt mine of mercury is that of Almaden, in Spain. (*q*)

that one part of charcoal-duſt to eight parts of ore was the beſt proportion.

When iron is ſurrounded by charcoal, it is not decompoſed or deſtroyed: hence the iron of the ore, which ſinks into the hollow made of paſte of charcoal-duſt and clay, remains there unhurt. The clay is added in this paſte to render it more compact, and to keep the fluid iron collected together.

The air is directed betwixt the crucibles; becauſe if it was thrown directly upon them, they would ſcarcely be able to reſiſt the heat. The ſpace betwixt the air-pipe and the crucibles ought to be conſtantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is ſeldom obtained in this firſt operation. The ſulphur and arſenic, and frequently alſo an earthy matter adhering to the iron, prevent theſe qualities.

(*q*) Ores *of* Mercury. Beſides the ores of mercury enumerated by the author of the Dictionary, Linnæus and Cronſtedt mention a ſingular ore, in which the mercury is *mineraliſed by ſulphur and by copper*. It is ſaid to be of a blackiſh-grey color, of a glaſſy texture, and brittle. When the mercury and ſulphur are expelled by fire, the copper is diſcovered by giving an opake red color to glaſs of borax, which, by continuance and encreaſe of heat, becomes green and tranſparent. *See* Cinnabar.

Cramer directs, that *ores of mercury ſhould be eſſayed* by the following Proceſſes:

PROCESS I.

[*Cramer's Art of Aſſaying, Proc.* 58.]

“ *To ſeparate Mercury out of an unſulphureous Ore by Diſtillation.*

“ TAKE a lump of the pulveriſed ore, one common pound, which muſt ſtand for one centner: put it into a glaſs retort perfectly clean, well loricated, or coated up to half the length of its neck: this muſt be very long, and turned backwards with ſuch a declivity, that a glaſs recipient may be perpendicularly applied to it; but you muſt chuſe a retort ſmall enough, that the belly of it may be filled hardly two-thirds with the ore: this retort muſt be placed ſo, that nothing of the fluid adherent to the neck of it may fall into the cavity of the belly, but that the whole may run forward into the recipient. Finally, have a ſmall recipient full of cold water: let it be perpendicularly ſituated, and receive the neck of the retort in ſuch manner that the extremity of it be hardly one half-inch immerſed into the water.

“ Let the retort be ſurrounded with hot burning coals placed at ſome diſtance in form of a circle, leſt the veſſel ſhould burſt by too ſudden a heat: then by degrees bring the burning coals nearer and nearer, and at laſt ſurround the whole retort with them and with freſh charcoal, that it may grow ſlightly red-hot: this fire having been continued for an hour, let the retort cool of itſelf: then ſtrike the neck of it gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and the water ſeparated from the mercury by filtration, and let the mercury be weighed. This operation may be more conveniently performed in a ſand bath, in which caſe the pot containing the ſand muſt be middling red-hot, and the retort be able to touch the bottom of it immediately; nor is it then neceſſary that the retort be loricated.”

PROCESS II.

[*Cramer's Art of Aſſaying, Proc.* 59.]

“ *To revive Mercury from a ſulphureous Cinnabar-ore.*

“ BEAT your ore extremely fine, and mix it exactly with an equal portion of iron-filings, not ruſty; and proceed to diſtill it with the ſame apparatus as in the former Proceſs; but urge it with the ſtrongeſt fire that can be made,

“ Cinnabar may be ſeparated from ſtones by ſublimation thus: Beat it to a fine powder, and put it into a ſmall, narrow glaſs or earthen cucurbit, the belly of which it muſt not fill more than one-third part: ſtop the orifice at top; this

DXVIII. ORE *of the* REGULUS *of* ANTIMONY, *or* ANTIMONY. Native regulus of antimony was firſt obſerved by Mr. Swab, in Sweden, in the mine of Salberg, and deſcribed by him in the Memoirs of the Swediſh Academy in 1749. Mr. Wallerius mentions it in his Mineralogy.

Regulus of antimony is generally united with ſulphur, with which it forms antimony, which ought to be conſidered as a true ore of the regulus of antimony.

Another ore of regulus of antimony is alſo known, of a red color, in which the regulus is mineraliſed both by arſenic and by ſulphur. This ore reſembles ſome iron ores, and ſome kinds of blend. It is diſtinguiſhed by its great fuſibility, which is ſuch, that it may be eaſily melted by the flame of a candle. (*r*)

“ muſt be very narrow, to hinder the free action of the air. Put this ſmall cucurbit in an earthen pot above two inches wide in diameter, and gather ſand around this pot about as high as the pulveriſed ore riſes in the cucurbit. Then put it upon burning coals in ſuch manner that the bottom of the pot may be middling red-hot. Thus will your cinnabar aſcend and form a ſolid ponderous ring, which muſt be got out by breaking the veſſel.”

(*r*) ORES *of* REGULUS *of* ANTIMONY. 1. The *native regulus* of antimony, obſerved by Mr. Von Swab, is ſaid by that author to have differed from the regulus of antimony obtained from ores, in theſe two properties, that it was capable of being eaſily amalgamated with mercury, and that its calx ſhot into cryſtals during the cooling.

Beſides the ores of regulus of antimony enumerated in the Dictionary, this ſemimetal is alſo found in ores of other metallic ſubſtances, as in the *plumoſe ſilver-ore*, and in the *ſtibiated lead-ore*. *See* ORES *of* SILVER *and of* LEAD.

The *ores of antimony may be eſſayed* by the following proceſſes deſcribed by Mr. Cramer.

PROCESS I.

(Cramer's Art of Aſſaying, Proceſs lx.)

“ *To obtain antimony from its ore.*

“ CHUSE a melting crucible or an earthen pot not glaz'd that may contain ſome common pounds of the ore of antimony, broken into ſmall bits. Bore at the bottom of the crucible ſome ſmall holes, two lines in diameter. Let the bottom of the veſſel be received by the orifice of a ſmaller one, upon which it muſt be put; and when the ore is put into it, let it be covered with a tile, and all the joints be ſtopt with lute.

“ Put theſe veſſels upon the pavement of a hearth, and put ſtones all round them at the diſtance of ſix inches. Fill this intermediate ſpace with aſhes, ſo high that the inferior pot be covered to the upper brim. Then put freſh and burning coals upon it, and with a pair of hand-bellows excite the fire, till the upper veſſel grows red-hot: take off the fire a quarter of an hour after, and when the veſſels are grown cold, open them. You will find that the melted antimony has run through the holes made at the bottom of the upper veſſel into the inferior one, where it is collected.

PROCESS II.

[Cramer's Art of Aſſaying, Proc. lxi.]

“ *To roaſt crude antimony, or its ore, with or without addition.*

“ CHUSE an earthen, flat, low diſh, not glaz'd, and if it cannot bear being made middling red-hot, cover it over with a coat of lute without. Spread it thinly over with crude antimony, or with its ore, beaten to a pretty coarſe powder, not exceeding a few ounces at once. Put the diſh upon a fire-pan, having a few burning coals in it: increaſe the fire till it begins to ſmoke a little. Meanwhile you

“ muſt

DXIX. **ORES *of* BISMUTH.** Biſmuth is chiefly mineraliſed by arſenic, and generally it is united with other ores, particularly with that of cobalt. (*s*)

“ muſt inceſſantly move the powder with a piece of new tobacco-pipe; for this cauſes the ſulphur to evaporate the ſooner. If you encreaſe the fire a little too ſoon, the powder immediately gathers into large clots, or even begins to melt. When this happens, take it immediately off the fire before it melts entirely. Then pulveriſe it again, and finally make a gentle fire under it. Your black ſhining powder will aſſume an aſh-color almoſt like that of earth, and become more refractory in the fire; wherefore you may then encreaſe the fire till your powder grows middling red-hot, and let it laſt till it ceaſes to ſmoke. If you add to your crude antimony pulveriſed, half or an equal quantity of charcoal duſt, and perform the reſt as above, the roaſting will be done more conveniently: for it does not gather ſo eaſily into clots, and melts with much greater difficulty. When part of the ſulphur is evaporated, add ſome fat to it at ſeveral times. Thus you will ſooner finiſh the operation, and the remaining calx will not be burnt to exceſs. However, if it be thus expoſed to too violent and long-laſting a fire, a great quantity of it evaporates; nor does it ceaſe entirely to ſmoak in a great fire. And it will be enough, if growing middling red-hot, it does no longer emit the unpleaſant ſmell of the acid of ſulphur.”

PROCESS III.

[Cramer, *Proc.* lxii.]

“ *To reduce a calx of antimony into a ſemimetallic regulus.*

“ MIX ſome calx of antimony with a quarter part of the black flux, and put it into the crucible. Cover the veſſel with a tile; make the fire as quickly as the veſſel can bear it, but not greater than is neceſſary to melt the flux. When the whole has been well in fuſion for half a quarter of an hour (which may be tried with a tobacco-pipe, taking off the tile) pour it into the melting cone, which muſt be warm and done over with tallow. Then immediately ſtrike the cone ſeveral times. You will find, when the cone is inverted, a regulus, above which is a ſaline ſcoria.”

The methods of *calcining antimony by means of nitre*; of obtaining a *regulus of antimony* without a previous calcination or roaſting, by throwing a mixture of powdered antimony, tartar, and nitre into a red-hot crucible, and by fuſing this mixture; and of obtaining a *martial regulus of antimony*; are deſcribed at the articles of the Dictionary, ANTIMONY, *and* REGULUS *of* ANTIMONY.

(*s*) ORES *of* BISMUTH. I. Biſmuth is found *native*, reſembling the regulus of biſmuth. II. An *ochre* of biſmuth, of a whitiſh yellow color, is mentioned by Cronſtedt, and is different from the ore improperly called *flowers of biſmuth*, which is a calx of cobalt. III. Biſmuth is mineraliſed; 1. By *ſulphur*. This ore has the appearance of galena. 2. With *ſulphurated iron.* Biſmuth is found alſo in cobalts (*ſee* COBALT), and in ſome ores of ſilver.

Ores of Biſmuth may be *eſſayed* by the following proceſs.

PROCESS I.

[Cramer, Proc. lxiv.]

“ *To melt biſmuth from its ore.*

“ BISMUTH ore may be melted with the ſame apparatus as was directed for the fuſion of crude antimony out of its ore. [*See* ORES *of* ANTIMONY.] Or you may beat your ore to a very fine powder, with the black flux, ſandiver, and common ſalt, in a cloſe veſſel, like the ore of lead, or of tin, and melt it in a middling fire, having a draught of air. But as this ſemimetal is deſtructible and volatile, you muſt as quick as poſſible apply to it that degree of fire which the flux requires to be melted; and ſo ſoon as it is well melted, the veſſel muſt be taken out of the fire; and when it is grown quite cold and broken, you will find your regulus.”

Mr. Gellert directs that ores of biſmuth ſhould be eſſayed by fuſing a quintal of pulveriſed ore with half a quintal of calcined

DXX. ORES *of the* REGULUS *of* COBALT, *or* COBALT. Cobalt is a grey-colored mineral, with more or leſs of a metallic appearance. Its grain is cloſe; it is compact and heavy, and frequently covered with an effloreſcence of peach-colored flowers. Of this ſeveral kinds are known. All the true cobalts contain the ſemimetal called *regulus of cobalt*, the calx of which becomes blue by vitrification. This regulus is mineraliſed in cobalt by ſulphur, and eſpecially by a large quantity of arſenic. Some cobalts alſo contain biſmuth and ſilver.

Authors have given the name of cobalt to many minerals, although they do not contain the ſemimetal above-mentioned, but only becauſe they externally reſemble the ore of the regulus of cobalt. But theſe minerals can only be conſidered as falſe cobalts. They are diſtinguiſhable from true cobalt by trying whether they can yield the blue glaſs called ſmalt, and the ſympathetic ink. The red effloreſcence is alſo a mark by which true cobalt is diſtinguiſhable from the falſe: but this effloreſcence only happens when the ore has been expoſed to a moiſt air.

The principal mines of cobalt are in Saxony, where they are dug for the ſake of obtaining zaffre, azure-blue, or ſmalt, and arſenic. Very fine cobalt is alſo found in the Pyrenean mountains.

Cobalt is heavier than moſt other ores, from the large quantity of arſenic it contains; and in this reſpect it reſembles the ore of tin. (*t*)

DXXI. ORES *of* ZINC. The proper ore of zinc is a ſubſtance which has rather an earthy or ſtoney than metallic appearance, and is called *calamy*, *calamine*, or *lapis calaminaris*. This ſtone, although metallic, is but moderately heavy, and has not the brilliancy of moſt other ores. Its color is yellow, and like that of ruſt. It is alſo leſs denſe than other metallic minerals. It ſeems to be an ore naturally decompoſed. The calamine is not worked directly to obtain zinc from it, becauſe this would only ſucceed in cloſe veſſels, and conſequently with ſmall quantities, according to Mr. Margraaf's proceſs. But it is ſucceſsfully employed for the converſion of copper into braſs by cementation, by which the exiſtence of zinc in that ſtone is ſufficiently proved.

Mr. Wallerius enumerates alſo amongſt the ores of zinc a very compounded mineral, conſiſting of zinc, ſulphur, iron, and arſenic. This mineral called *blend* reſembles externally the ore of lead, and hence has been called *falſe galena*. Theſe blends have different forms and colors, but are chiefly red, like the red ore of antimony.

Zinc is obtained from certain minerals in the Eaſt Indies, of which we know little. (*u*)

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borax, and half a quintal of pulveriſed glaſs, in order to vitrify the adherent earths and ſtones which invelop the biſmuth. But probably the heat requiſite for this vitrification would volatiliſe part of the biſmuth.

If the ore be of the kinds above deſcribed, mineraliſed by ſulphur, or by ſulphur and iron, a previous roaſting would be expedient, which may be performed in the ſame manner as is directed for the roaſting of antimony.

(*t*) The ores of cobalt are enumerated in a note under the article COBALT. The *eſſay* of cobalt is deſcribed at the article REGULUS *of* COBALT.

(*u*) ORES *of* ZINC. I. *Calciform ores* of zinc, according to Cronſtedt, are pure or mixed. The pure are indurated, and ſometimes cryſtalliſed, reſembling lead-ſpar. The mixed

DXXII. ORES *of* ARSENIC. The minerals which contain the largeſt quantity of arſenic are cobalts and white pyrites, although it is alſo contained in other ores, it being one of the mineraliſing ſubſtances. But as cobalt muſt be roaſted to obtain the ſulphur it contains, the arſenic alſo which riſes during this torrefaction is collected, as we ſhall ſee in the article SMELTING *of* ORES, *and the particular articles of each of the metallic ſubſtances mentioned in this article.* (*x*)

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mixed ore contains alſo ſome calx of iron. This is *calamine.* It is whitiſh, yellowiſh, reddiſh, or brown. II. Zinc is *mineraliſed,* 1. *By ſulphurated iron. Ore of zinc.* Wallerius ſays, lead is ſometimes contained in this ore. It is white, blue, or brown. 2. *By ſulphur, arſenic, and iron. Blend,* or *pſeudo-galena* or *falſe-galena,* or *black-jack.* See FALSE-GALENA. Theſe are of various colors, white, yellowiſh, brown, reddiſh, greeniſh, black. They conſiſt of ſcales, or are teſſelated. Mr. Cronſtedt thinks, that in blends the zinc is mineraliſed in the ſtate of a calx, and in the ore of zinc, in its metallic ſtate.

Although the minerals above enumerated have been known, from their property of converting copper into braſs, to be ores of zinc, yet the method of eſſaying them ſo as to obtain the contained zinc was not known, or at leaſt not publiſhed, before Mr. Margraaf's Memoir of the Berlin Academy for the year 1746, upon that ſubject. That very able chemiſt has ſhewn that zinc may be obtained from its ores, from the flowers, or from any other calx of zinc, by treating theſe with charcoal duſt, in cloſe veſſels, to prevent the combuſtion of the zinc, which happens immediately upon its reduction, when expoſed to air. For this purpoſe, he put a quantity of finely powdered calamine, or roaſted blend, or other calx of zinc, well mixed with an eighth part of charcoal-duſt, into a ſtrong, luted earthen retort, to which he fitted a receiver. Having placed his retort in a furnace and raiſed the fire, he applied a violent heat during two hours. When the veſſels were cold, and broken, he found the zinc in its metallic form adhering to the neck of the retort.

The chief difficulty in this operation is to get an earthen retort ſufficiently compact to retain the vapor of the zinc, (for it eaſily pervades the Heſſian crucibles, Stourbridge melting-pots, and ſimilar veſſels, as may be ſeen from the quantity of flowers which appear upon their outer ſurface, when zinc or its calxes and any inflammable matter have been expoſed to heat within theſe veſſels) and at the ſame time ſufficiently ſtrong to reſiſt the violent fire which Mr. Margraaf requires.

A pretty exact eſſay of an ore of zinc may be made in the following manner.

Mix a quantity of pulverized roaſted ore or calx of zinc with an eighth part of charcoal-duſt. Put this mixture into a crucible capable of containing thrice the quantity. Diffuſe equally amongſt this mixture a quantity of ſmall grains or thin plates of copper equal to that of the calamine or ore employed, and upon the whole lay another equal quantity of grains or plates of copper; and laſtly, cover this latter portion of copper with charcoal-duſt. Lute a lid upon the crucible; and apply a red heat during an hour or two. The copper or part of it will unite with the vapor of the zinc, and be thereby converted into braſs. By comparing the weight of all the metal after the operation with the weight of the copper employed; the weight acquired, and conſequently the quantity of zinc united with the copper, will be known. The copper which has not been converted into braſs, or more copper with freſh charcoal-duſt, may be again added in the ſame manner to the remaining ore, and the operation repeated with a heat ſomewhat more intenſe, that any zinc remaining in the ore may be thus extracted. A curious circumſtance is, that a much greater heat is required to obtain zinc from its ore, by diſtillation, than in the operation, now deſcribed, of making braſs; in which the ſeparation of the zinc from its ore ſeems to be facilitated by its diſpoſition to unite with copper.

(*x*) ORES *of* ARSENIC. I. Regulus of arſenic is found *native.* It is of a leaden color; it burns with a ſmall flame; and is diſſipated, leaving generally a very ſmall quantity of calx of biſmuth, or of calx of cobalt, and a very little ſilver. When it is of a ſolid and

DXXIII. OSTEOCOLLA. (y)

teſtaceous texture, it has been improperly called *teſtaceous cobalt*, in German, *ſcherben-cobalt*. II. Calx of arſenic is found in form of powder: *native flowers of arſenic*; or of indurated ſemitranſparent cryſtals; *native cryſtalline arſenic*. III. Calx of arſenic is mixed, 1. With *ſulphur*: when yellow, it is called *orpiment*; when red, it is called *native realgar*: the difference of color depends on the proportion of the two component parts. 2. With *calx of tin*; *tin-grains*. 3. With ſulphur and ſilver, in the *red ſilver-ore*. 4. With *calx of lead*, in the *lead-ſpar*. 5. With calx of cobalt, in the *efflorescence of cobalt*. IV. Arſenic is *mineraliſed*; 1. With *ſulphurated iron*; *arſenical pyrites*. 2. With *iron* only; *white pyrites*, or *miſpickel*. 3. With *cobalt*, in all almoſt cobalt-ores. 4. With *ſilver*. See Ores *of* Silver. 5. With *copper*. See Ores *of* Copper. 6. With *antimony*. See Ores *of* Antimony. *Cronſtedt*.

Arſenic may be ſeparated from its ore or earthy matters, with which it happens to be mixed, *by ſublimation*, according to the following proceſs of Mr. Cramer. [Art of Aſſaying, Proc. lxix.]

" DO every thing as was ſaid about mercury, or ſulphur; but let the veſſel which " is put into the fire with the ore in it " be of earth or ſtone, and the recipient be " of glaſs, and of a middling capacity. " Nor is it neceſſary that this ſhould be filled with water, ſo it be but well luted. " The fire muſt likewiſe be ſtronger, and " continued longer than for the extracting " of ſulphur. Nevertheleſs every kind of " arſenic cannot be extracted in a confined " fire: for it adheres to the matrix more " ſtrongly than ſulphur and mercury. You " will find in the part of the veſſel which is " more remote from the fire, pulverulent " and ſubtle flowers of arſenic; but there will " adhere to the poſterior part of the neck " of the retort ſmall ſolid maſſes, ſhining " like ſmall cryſtals, tranſparent, ſometimes " gathered into a ſolid ſublimate, and perfectly white, if the ore of the arſenic was " perfectly pure; which, nevertheleſs, happens very ſeldom. The flowers are moſt " commonly thin, and of a grey color: " which proceeds from the phlogiſton mixt " with the maſs. They are often of a citron " or of a golden color, which is a ſign that " there is in the mixture ſome mineral ſulphur; and if the ſublimate be red or yellow, it is a ſign of much ſulphur.

" As all the arſenic contained in the ore is " not expelled in cloſe veſſels, you muſt " weigh the reſiduum; then roaſt it in a crucible till it ſmoaks no longer, or rather in " an earthen flat veſſel not glazed, and in a " ſtrong fire to be ſtirred now and then with " a poker, and then weigh it when grown " cold: you will be able thus to know how " much arſenic remained in the cloſe veſſel; " unleſs the ore contain biſmuth."

If the arſenic be ſulphurated, it may be purified by triturating it with mercury or with fixed alkali, and by ſubliming the arſenic from the remaining ſulphurated mercury or alkali. *See* Arsenic. The method of obtaining a regulus of arſenic is deſcribed at the article Regulus *of* Arsenic.

(y) Osteocolla is a ſubſtance formed by ſtoney matters filling up the interſtices of rotten roots of trees. It has been particularly deſcribed by Mr. Gleditſch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the Year 1748. The former author relates, that it is dug from grounds containing fine ſand and a fine calcareous earth; and that ſometimes the roots of living trees had been found converted into this ſtoney ſubſtance. From Mr. Margraaf's experiments we find, that the oſteocolla examined by him was compoſed of a fine ſand, a fine calcareous earth, and ſome rotten remains of a root. Neuman alſo ſays, that he found marine acid in oſteocolla. But nothing of that or any other acid could be diſcovered by Margraaf. Neuman alſo ſays, that he totally diſſolved oſteocolla by means of dilute vitriolic acid. Hence the ſubſtances examined by theſe two chemiſts ſeem to have been different. Differences muſt ariſe from the different qualities of the ſoil in which oſteocolla is found.

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DXXIV. **PANACEA (MERCURIAL).** This name, which ſignifies *univerſal remedy*, is given to a preparation of mercury much employed in the cure of thoſe diſeaſes, againſt which that metallic ſubſtance is effectual. To make the panacea, ſweet mercury is to be taken and ſublimed nine times, then reduced to a fine powder, and digeſted in good ſpirit of wine, which is, laſtly, to be diſtilled off, or only decanted.

Sweet mercury is corroſive ſublimate entirely ſaturated with mercury, and thrice ſublimed. Corroſive ſublimate is rendered milder by the operations which change it into ſweet mercury, and retains nothing of its cauſticity but a purgative quality; but by the nine ſublimations which change ſweet mercury into the panacea, the ſaline qualities of this mercurial preparation are ſo diminiſhed, that after all theſe ſublimations it has not even a purgative virtue.

Theſe changes are probably produced, becauſe at each ſublimation a ſmall quantity of marine acid is ſeparated; ſo that the panacea contains but very little of this acid, and is little elſe than very pure mercury, united with that quantity only of marine acid, which is neceſſary to deprive it of its fluid metallic form, and to give it a ſaline appearance.

The panacea therefore taken internally produces only the effects of mercury much divided, and in ſuch a ſtate that its molecules may be divided more and more by the action of the veſſels and liquors of the body, without being capable of uniting again ſo as to form fluid mercury. This remedy is therefore very proper for exciting ſalivations, and produces nearly the ſame effects as mercury adminiſtered by friction and fumigation.

We may employ the panacea with ſucceſs in venereal diſeaſes, and in others in which preparations of mercury are ſuitable. It may be given conveniently in pills or in a bolus, mixed with proper ſubſtances, and cannot be given in any other manner, becauſe it is inſoluble, and is very heavy. The doſe of it is from ſix to twenty-four grains, and even more in ſome circumſtances. *See the article* MERCURY, *for the medicinal uſes of this preparation.*

DXXV. PARTING. Parting is an operation by which gold and ſilver are ſeparated from each other. As theſe two metals reſiſt equally well the action of fire and of lead, they muſt therefore be ſeparated by other methods. This ſeparation could not be effected, if they were not ſoluble by different menſtruums.

Nitrous acid, marine acid, and ſulphur, which cannot diſſolve gold, attack ſilver very eaſily; and therefore theſe three agents furniſh methods of ſeparating ſilver from gold, or of the operation called *parting*.

Parting by nitrous acid is the moſt convenient, and therefore moſt uſed, and even almoſt the only one employed by goldſmiths and coiners. Wherefore it is called ſimply *parting*. That made with the marine acid is only made by cementation, and is known by the name of *concentrated parting*. Laſtly, parting by ſulphur is made by fuſion, which the chemiſts call the *dry way*, and is therefore called *dry parting*. We ſhall deſcribe each of theſe methods.

DXXVI. PARTING *by* AQUA FORTIS. Although parting by aqua fortis be eaſy, as we have ſaid, it cannot however ſucceed, or be very exact, unleſs we attend to ſome eſſential circumſtances.

1. The gold and ſilver muſt be in a proper proportion; for if the gold was in too great quantity, the ſilver would be covered and guarded by it from the action of the acid.

Therefore when eſſayers do not know the proportion of theſe two metals in the maſs to be operated upon, they diſcover it by the following method.

They have a certain number of needles compoſed of gold and ſilver allayed together in graduated proportions, and the allay of each needle is known by a mark upon it. Theſe are called *proof-needles*.

When eſſayers want to know nearly the proportion of gold and ſilver in a maſs, they rub this maſs upon a touchſtone, ſo as to leave a mark upon it. They then make marks upon the touch-ſtone with ſome of the needles the color of which they think comes neareſt to that of the maſs. By comparing the marks of theſe needles with the mark of the maſs, they diſcover nearly the proportion of the gold and ſilver in the maſs.

If this trial ſhews that in any given maſs the ſilver is not to the gold as three to one, this maſs is improper for the operation of parting by aqua fortis. In this caſe, the quantity of ſilver neceſſary to make an allay of that proportion muſt be added.

This operation is called *quartation*, probably becauſe it reduces the gold to a fourth part of the whole maſs.

2. That the parting may be exact, the nitrous acid or aqua fortis employed muſt be very pure, and eſpecially free from mixture of vitriolic and marine acids. Its purity muſt therefore be aſcertained; and if this be found not ſufficient, the acid muſt be purified by an operation called the *precipitation of* AQUA FORTIS. *See that article.*

If the purity of the aqua fortis was not attended to, a quantity of ſilver proportionable to theſe two foreign acids would be ſeparated during the ſolution; and this portion of ſilver, reduced by theſe acids to vitriol of ſilver and to luna cornea, would remain mingled with the gold, which conſequently would not be entirely purified by the operation.

When the metallic maſs is properly allayed, it is to be reduced to plates, rolled up ſpirally, called cornets; or to grains. Theſe are to be put into a matraſs, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the ſilver as three to two: and as the nitrous acid employed for this operation is rather weak, the ſolution is aſſiſted, eſpecially at firſt, by the heat of a ſand-bath, in which the matraſs is to be placed. When, notwithſtanding the heat, no further mark of ſolution appears, the aqua fortis charged with ſilver is to be decanted. Freſh nitrous acid is to be poured into the matraſs, ſtronger than the former, and in leſs quantity, which muſt be boiled on the reſiduous maſs, and decanted as the former. Aqua fortis muſt even be boiled a third time on the remaining gold, that all the ſilver may be certainly diſſolved. The gold is then to be waſhed with boiling water. This gold is very pure, if the operation has been performed with due attention. It is called *gold of parting*.

No addition of ſilver is required, if the quantity of ſilver of the maſs is evidently much more conſiderable than that of the gold: perſons who have not proof needles, and other apparatus to determine the proportion of the allay, may add to the gold an indeterminate quantity of ſilver, obſerving that this quantity be rather too great than too ſmall, and ſo conſiderable as to render the maſs nearly as white as ſilver; for a large quantity of ſilver is rather favorable than hurtful to the operation: It has no other inconvenience than an uſeleſs expence, as the larger the quantity is of ſilver, the more aqua fortis muſt be employed. We ought to attend to this fact, that the color of gold is ſcarcely perceptible in a maſs two-thirds of which is ſilver and one-third is gold; this color then muſt be much leſs perceptible when the gold is only one-fourth part, or leſs, of the whole maſs.

If the quantity of gold exceeds that of the ſilver, the maſs may be expoſed to the action of aqua regia, which would be a kind of inverſe parting, becauſe the gold is diſſolved in that menſtruum, and the ſilver is not, but rather reduced to a luna cornea, which remains in form of a precipitate after the operation. But this method is not much practiſed, for the following reaſons.

Firſt, the gold cannot be eaſily ſeparated from the aqua regia; for if the parting has been made with an aqua regia prepared with ſal ammoniac, or if the gold be precipitated by a volatile alkali, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia has been made with ſpirit of ſalt, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very ſlow, and probably incompleat. *See* GOLD (FULMINATING).

Secondly, in the parting by aqua regia, the ſilver is indeed precipitated into a luna cornea, and thus ſeparated; but this ſeparation is not perfect, as a ſmall quantity of luna cornea will always remain diſſolved by the acids, if this ſolution even could be only effected by the ſuperabundant water of theſe acids. Accordingly the ſilver is not ſo accurately ſeparated from the gold by aqua regia, as the gold is from the ſilver by aqua fortis. We ſhall afterwards ſee, at the article PARTING (CONCENTRATED), that by this operation, ſilver may be ſeparated from gold without the neceſſity of quartation, although theſe metals ſhould not be in a proper proportion for the parting by aqua fortis.

The gold after the parting by aqua fortis is much more eaſily collected when it remains in ſmall maſſes, than when it is reduced to a powder.

When the maſs has been regularly quarted, that is, when it contains three parts of ſilver and one part of gold, we muſt employ, particularly for the firſt ſolution, an aqua fortis ſo weakened that heat is required to aſſiſt the ſolution of the ſilver: by which means the ſolution is made gently; and the gold which remains preſerves the form of the ſmall maſſes before the ſolution. If the aqua fortis employed were ſtronger, the parts of the gold would be diſunited and reduced to the form of a powder, from the activity with which the ſolution would be made.

We may indeed part by aqua fortis a maſs containing two parts of ſilver to one part of gold; but then the aqua fortis muſt be ſtronger; and if the ſolution be not too much haſtened, the gold will more eaſily remain in maſſes after the operation. In both caſes, the gold will be found to be tarniſhed and blackened, probably from the phlogiſton of the nitrous acid. Its parts have no adheſion together, becauſe the ſilver diſſolved from it has left many interſtices; and the cornets or grains of this gold will be eaſily broken, unleſs they be handled very carefully. To give them more ſolidity, they are generally put into a teſt under a muffle and made red-hot, during which operation they contract conſiderably, and their parts are approximated. Theſe pieces of gold are then found to be rendered much more ſolid, ſo that they may be handled without being broken. By this operation alſo the gold reſumes its color and luſtre; and as it generally has the figure of cornets, it is called *gold in cornets*, or *grain gold*. Eſſayers avoid melting it, as they chuſe to preſerve this form, which ſhews that it has been parted.

The gold and ſilver thus operated upon ought to have been previouſly refined by lead, and freed from all allay of other metallic matters, ſo that the gold which remains ſhould be as pure as is poſſible. However, as this is the only metal which reſiſts the action of aqua fortis, it might be purified by parting from all other metallic ſubſtances; but this is not generally done for ſeveral reaſons. Firſt, becauſe the refining by lead is more expeditious and convenient for the ſeparation of the gold from the imperfect metals; and ſecondly, becauſe the ſilver, when afterwards ſeparated from the aqua fortis, is pure; laſtly, becauſe moſt imperfect metals do not remain completely and entirely diſſolved in nitrous acid, from the portion of phlogiſton which this acid deprives them of, the gold would be found after the parting mixed with the part of theſe metals which is precipitated.

The gold remaining after the parting ought to be well waſhed, to cleanſe it from any of the ſolution of ſilver which might adhere to it; and for this purpoſe diſtilled water ought to be uſed, or at leaſt water the purity of which has been aſcertained by its not forming a precipitate with a ſolution of ſilver, becauſe ſuch a precipitate would alter the purity of the gold.

The ſilver diſſolved in the aqua fortis may be ſeparated either by diſtillation, in which caſe all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by ſome ſubſtance which has a greater affinity than this metal with nitrous acid. Copper is generally employed for this purpoſe at the mint.

The ſolution of ſilver is put into copper veſſels. The aqua fortis diſſolves the copper, and the ſilver precipitates. When the ſilver is all precipitated, the new ſolution is decanted, which is then a ſolution of copper. The precipitate is to be well waſhed, and may be melted into an ingot. It is called *parted ſilver.* When this ſilver has been obtained from a maſs which had been refined by lead, and when it has been well waſhed from the ſolution of copper, it is very pure.

Mr. Cramer obſerves juſtly in his Treatiſe on Eſſaying, that however accurately the operation of parting has been performed, a ſmall portion of ſilver always remains united with the gold, if the parting has been made by aqua fortis; or a ſmall portion of the gold remains united with the ſilver, if the parting has been made by aqua regia; and he eſtimates this ſmall allay to be from a two hundredth to a hundredth and fiftieth part, which quantity may be conſidered as nothing for ordinary purpoſes, but may become ſenſible in accurate chemical experiments. (z)

(z) The maſs of gold and ſilver to be quarted, ought previouſly to be *granulated*, which may be done by melting it in a crucible, and pouring it into a large veſſel full of cold water, while at the ſame time a rapid circular motion is given to the water by quickly ſtirring it round with a ſtick or broom.

The veſſels generally uſed for this operation, called *parting-glaſſes*, have the form of truncated cones, the bottom being commonly about ſeven inches wide, the aperture about one or two inches wide, and the height about twelve inches. Theſe glaſs veſſels ought to have been well annealed, and choſen free from flaws; as one of the chief inconveniencies attending the operation is, that the glaſſes are apt to crack, by expoſure to cold, and even when touched by the hand. Some operators ſecure their glaſſes by a coating. For this purpoſe they ſpread a mixture of quicklime ſlaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the veſſel, leaving the upper part uncovered, that they may ſee the progreſs of the operation; and over this cloth they apply a compoſition of clay and hair. Schlutter adviſes to put the parting-glaſſes in copper veſſels containing ſome water, and ſupported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminiſhed by adding cold water, which muſt be done very carefully by pouring againſt the ſides of the pan, to prevent too ſudden an application of cold to the parting-glaſs. The intention of this contrivance is, that the contents of the glaſſes, if theſe ſhould break, may be received by the copper veſſel. Into a glaſs fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper-pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he uſually put about eighty ounces of metal, with twice as much aqua fortis.

The *aqua fortis* ought to be ſo ſtrong as to be capable of acting ſenſibly on ſilver when cold, but not ſo ſtrong as to act violently. If the aqua fortis be very ſtrong, however pure, and if the veſſels be well cloſed, a ſmall quantity of the gold will be diſſolved along with the ſilver, which is to be guarded againſt.

Little *heat* ought to be applied at the beginning, the liquor being apt to ſwell and riſe over the veſſel; but when the acid is nearly ſaturated, the heat may be ſafely encreaſed.

When the ſolution ceaſes, which may be known by the diſcontinuance of the effervеſcence, or emiſſion of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis muſt be added, that all the ſilver may be diſſolved. If the operation has been performed ſlowly, the remaining gold will have ſtill the form of diſtinct maſſes, which are to receive ſolidity and color by fire, in the manner directed by the author of the Dictionary. If the operation has been performed haſtily, the gold will have the appearance of a black mud or powder, which after five or ſix waſhings with pure water muſt be melted.

The *ſilver is uſually recovered* by precipitating it from the aqua fortis by means of copper-veſſels into which the liquor is poured.

DXXV. PARTING (CONCENTRATED). Concentrated parting is alſo called *parting by cementation*, becauſe it is actually performed by cementation. This parting or purification of gold is uſed when the quantity of it is ſo great in proportion to the ſilver, that it cannot be ſeparated by aqua fortis. This operation is done in the following manner.

A cement is firſt prepared compoſed of four parts of bricks powdered and ſifted, of one part of green vitriol calcined till it becomes red, and of one part of common ſalt. The whole is very accurately mixed together, and a firm paſte is made of it by moiſtening it with a little water or urine. This cement is called *cement royal*, becauſe it is employed to purify gold, which is conſidered by chemiſts as the king of metals.

The gold to be cemented is to be reduced to plates as thin as ſmall pieces of money. At the bottom of the crucible or cementing-pot, a ſtratum of cement, of the thickneſs of a finger, is to be put, which is to be covered with plates of gold; upon theſe another ſtratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with theſe alternate ſtrata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and ſand. This pot is to be placed in a furnace, or oven, and heated by degrees till it is moderately red, which heat is to be continued during 24 hours. The heat muſt not be ſo great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully ſeparated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be eſſayed upon a touchſtone or otherwiſe; and if it be found not ſufficiently purified, it is to be cemented a ſecond time in the ſame manner.

The vitriolic acid of the bricks and of the calcined vitriol diſengages the acid of the common ſalt during this cementation: and this latter acid diſſolves the ſilver allayed with the gold, and ſeparates it by that means.

This experiment proves, that although marine acid, while it is liquid, cannot attack ſilver, it is nevertheleſs a powerful ſolvent of that metal. But for this purpoſe it muſt be applied to the ſilver in the ſtate of vapors, extremely concentrated, and aſſiſted with a conſiderable heat. All theſe circumſtances are united in the concentrated parting.

This experiment proves alſo, that notwithſtanding all theſe circumſtances, which favour the action of the marine acid, it is incapable of diſſolving gold.

Laſtly, the marine acid in this ſtate more effectually diſſolves the ſilver than the nitrous acid does in the parting by aqua fortis, ſince this operation ſucceeds

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or of plates of copper which are thrown along with the liquor into glaſs-veſſels. A conſiderable heat is required to accelerate this precipitation. Dr. Lewis ſays, he has obſerved that when the aqua fortis was perfectly ſaturated with ſilver, no precipitation was occaſioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as uſual.

The precipitated ſilver muſt be well waſhed in boiling water, and fuſed with ſome nitre, the uſe of which is to ſcorify any cupreous particles, which may adhere to the ſilver.

From the ſolution of copper in aqua fortis, a blue pigment called *verditer* is obtained by precipitation with whiting. *See* VERDITER.

well when the ſilver is in ſo ſmall a proportion as that it would be protected from the action of the nitrous acid in the ordinary parting.

Inſtead of ſea ſalt, nitre may be uſed with equal ſucceſs; becauſe the nitrous acid is then put in a ſtate to attack the ſilver, notwithſtanding the quantity of gold which covers it.

Several chemiſts and artiſts uſe both nitre and common ſalt in the cement royal; which ſhews that the acids of aqua regia, applied in this manner at the ſame time to gold and to ſilver, attack the latter metal preferably to the former. (a)

The gold muſt be very carefully waſhed after the operation to cleanſe it from particles of diſſolved ſilver, which otherwiſe would ſtick to it.

The ſilver may be ſeparated from the cement by fuſion with a ſufficient quantity of lead and litharge, and by cupelling the lead which retains the ſilver. (b)

DXXVIII. PARTING (DRY). Dry parting, or parting by fuſion, is performed by ſulphur, which has the property of uniting eaſily with ſilver, while it does not attack gold.

This method of ſeparating theſe two metals would be the cheapeſt, the moſt expeditious and convenient of any, if the ſulphur could diſſolve the ſilver, and ſeparate it from the gold as well and as eaſily as nitrous acid does: but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the ſulphur with the ſilver allayed with gold. Then repeated and troubleſome fuſions muſt be made, in each of which we are obliged to add different intermediate ſubſtances, and particularly the metals which have the ſtrongeſt affinity with ſulphur, to aſſiſt the precipitation, which in that caſe does not give a regulus of pure gold, but a gold ſtill allayed with much ſilver, and even with a part of the precipitating metals; ſo that, to compleat the operation, cupellation is neceſſary, and alſo parting by aqua fortis.

From what we have ſaid concerning this operation we may perceive, that it ought not to be made but when the quantity of ſilver with which the gold is allayed is ſo great, that the quantity of gold which might be obtained by the ordinary parting is not ſufficient to pay the expences; and that it is only proper for concentrating a larger quantity of gold in a ſmaller quantity of ſilver. As this dry parting is troubleſome, and even expenſive, it ought not to be undertaken but on a conſiderable quantity of ſilver allayed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemiſts and artiſts who have given proceſſes for the dry parting, recommend its uſe only in the above-mentioned caſes. We wiſh that this operation could be improved: it would be much more advantageous, if it could be done by two or three fuſions; and if by theſe an exact ſeparation could be obtained of a ſmall quantity of gold mixed with a large quantity of ſilver. (c)

(a) By this method ſome of the gold would probably be diſſolved along with the ſilver. As no advantages are ſaid to attend it, to give it preference to cementation with nitre or with ſea-ſalt ſingly, Dr. Lewis does judiciouſly, I think, diſapprove of it.

(b) Gold is never purified by one operation of this kind. It muſt therefore be again melted, beat into plates, and cemented as before. The operation is troubleſome, and is now little uſed, excepting, as Dr. Lewis ſays, for extracting ſilver or baſe metals from the ſurface of gold, and thus giving to an alloyed metal the color and appearance of pure gold.

Under the article PURIFICATION *of* GOLD *by* ANTIMONY, we ſhall ſee that this purification is a true dry parting, and we ſhall there find the theory of what paſſes in that operation.

(c) As this operation for extracting a ſmall quantity of gold from a large quantity of ſilver is, notwithſtanding its inconveniences, approved by Schlutter, Scheffer, and other authors, and practiſed in Hartz, we ſhall add to the article in the Dictionary concerning it, what Dr. Lewis, in his excellent Hiſtory of Gold, has ſaid upon the ſubject.

The moſt advantageous method of ſeparating a ſmall portion of gold from a large one of ſilver appears to be by means of ſulphur, which unites with and ſcorifies the ſilver without affecting the gold: but as ſulphurated ſilver does not flow thin enough to ſuffer the ſmall particles of gold diffuſed through it to reunite and ſettle at the bottom, ſome addition is neceſſary for collecting and carrying them down.

In order to the commixture with the ſulphur, fifty or ſixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a ſmall crucible made red-hot, and pouring it into cold water ſtirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, according as it is richer or poorer in gold, is reſerved; and the reſt well mingled with an eighth of powdered ſulphur. The grains enveloped with the ſulphur are again put into the crucible, and the fire kept gentle for ſome time, that the ſilver, before it melts, may be thoroughly penetrated by the ſulphur; if the fire was haſtily urged, great part of the ſulphur would be diſſipated, without acting upon the metal.

If to ſulphurated ſilver in fuſion pure ſilver be added, the latter falls to the bottom, and forms there a diſtinct fluid, not miſcible with the other. The particles of gold, having no affinity with the ſulphurated ſilver, join themſelves to the pure ſilver wherever they come in contact with it, and are thus transferred from the former into the latter, more or leſs perfectly according as the pure ſilver was more or leſs thoroughly diffuſed through the mixed. It is for this uſe that a part of the granulated metal was reſerved. The ſulphurated maſs being brought into perfect fuſion, and kept melted for near an hour in a cloſe covered crucible, one third of the reſerved grains is thrown in; and as ſoon as this is melted, the whole is well ſtirred, that the freſh ſilver may be diſtributed through the mixed, to collect the gold from it. The ſtirring is performed with a wooden rod; an iron one would be corroded by the ſulphur, ſo as to deprive the mixed of its due quantity of ſulphur, and likewiſe render the ſubſequent purification of the ſilver more troubleſome. The fuſion being continued an hour longer, another third of the unſulphurated grains is added, and an hour after this the remainder; after which the fuſion is further continued for ſome time, the matter being ſtirred at leaſt every half hour from the beginning to the end, and the crucible kept cloſely covered in the intervals.

The ſulphurated ſilver appears in fuſion of a dark brown color: after it has been kept melted for a certain time, a part of the ſulphur having eſcaped from the top, the ſurface becomes white, and ſome bright drops of ſilver, about the ſize of peas, are perceived on it. When this happens, which is commonly in about three hours after the laſt addition of the reſerved grains, ſooner or later according as the crucible has been more or leſs cloſely covered, and the matter more or leſs ſtirred, the fire muſt be immediately diſcontinued; for otherwiſe more and more of the ſilver, thus [illegible] its ſulphur, would ſubſide and [illegible] with the part at the bottom in whic[illegible]ld is collected. The whole is p[illegible] out into an iron mortar greaſed and duſ[illegible] or if the quantity is too large to [illegible] ſafely lifted at once, a part is firſt laded out from the top with a ſmall crucible, and the reſt poured into the mortar. The gold, diffuſed at firſt through the whole maſs, is now found collected into a part of it at the bottom, amounting only to about as much as

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DXXIX. PELICAN. The pelican is a glaſs alembic conſiſting of one piece. It has a tubulated capital, from which two oppoſite and crooked beaks paſs out, and enter again at the belly of the cucurbit. This veſſel has been contrived for a continued digeſtion and cohobation, which chemiſts call *circulation*. The volatile parts of ſubſtances put into this veſſel riſe into the capital, and are obliged to return through the crooked beaks into the cucurbit; and this without interruption, or luting and unluting the veſſels.

Although the pelican ſeems to be a very convenient inſtrument, it is nevertheleſs little uſed, and even much neglected at preſent, either becauſe the modern chemiſts have not ſo much patience as the ancient chemiſts had, for making long experiments; or becauſe they find that two matraſſes, the mouth of one of which is inſerted into the mouth of the other, produce the ſame effect. *See Plate I.*

DXXX. PELLICLE. By this word chemiſts mean a very thin ſaline cruſt, which is formed upon the ſurface of ſolutions of ſalts, when they are evaporated to a certain degree. This pellicle is nothing elſe than a number of ſaline particles cryſtallized by evaporation at the ſurface of the liquor rather than any where elſe; becauſe the evaporation is made there. Theſe ſmall cryſtals of ſalt at firſt cover the ſurface of the liquor, and give it a duſky ap-

was reſerved unſulphurated. This part may be ſeparated from the ſulphurated ſilver above it by a chiſel and hammer; or more perfectly, the ſurface of the lower part being generally rugged and irregular, by placing the whole maſs with its bottom upwards in a crucible: the ſulphurated part quickly melts, leaving unmelted that which contains the gold, which may thus be conveniently ſeparated from the other. The ſulphurated ſilver is eſſayed, by keeping a portion of it in fuſion in an open crucible, till the ſulphur is diſſipated, and then diſſolving it in aqua fortis. If it ſhould ſtill be found to contain any [illegible] an hour and a half.

The gold thus collected into a part of the ſilver may be further concentrated into a [illegible]

of lead is at moſt forty pounds on a quintal or hundred pounds of the ore. The lead worked off on a teſt or concave hearth yields about a hundred and ten grains of ſilver, and the ſilver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting ſcarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above-mentioned confines this method of ſeparation to ſuch ſilver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a ſixty-fourth of the ſilver; he adviſes alſo not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the ſilver. Mr Scheffer, however, relates (in the Swediſh Memoirs for the year [illegible]) that he has by this method brought the gold to perfect fineneſs; and that he has likewiſe collected all the gold which the ſilver contained; the ſilver of the laſt operations, which had taken up a portion of the gold, being reſerved to be worked over again with a freſh quantity of gold-holding ſilver. The ſulphurated ſilver is purified by continuing it in fuſion for ſome time, with a large ſurface expoſed to the air; the ſulphur gradually exhales, and leaves the ſilver entire.

pearance, as if it were covered with duſt or with a very thin ſkin, from which appearance the name of pellicle has been given.

As all cryſtallizable ſalts may be cryſtallized by evaporation alone, in the ſolution therefore of any of theſe ſalts a pellicle may be formed; and alſo, as all ſolutions of ſalts, evaporated till a pellicle is formed, furniſh cryſtals by expoſing the liquor to cold, chemiſts have eſtabliſhed a general rule for cryſtallization, to evaporate ſolutions of ſalts till a pellicle is formed, and then to leave them to cryſtallize by expoſure to cold.

This rule is applicable to many ſalts, but is not general; for ſome ſalts, as common ſalt, do not cryſtallize by expoſure to cold, although the ſolution of them has been previouſly evaporated till a pellicle has been formed; while other ſalts, as nitre and Glauber's ſalt, may be cryſtallized in great quantities, although their ſolutions have not been evaporated ſo much as that a pellicle has been formed. Hence, to cryſtallize ſuch ſalts as common ſalt, the evaporation muſt be continued after the pellicle has been formed; and to obtain fine cryſtals of nitre, Glauber's ſalt, and others which cryſtallize in a ſimilar manner, the evaporation muſt not be continued till a pellicle is formed, but their ſolutions muſt be left to cool ſlowly before it has been ſo much evaporated. *See* CRYSTALLIZATION *of* SALTS

DXXXI. PENNY-WEIGHTS. Penny-weights are fictitious parts into which we ſuppoſe any maſs of ſilver to be divided, to ſpecify its degree of purity.

Any maſs of ſilver, the purity of which is to be examined, is ſuppoſed to conſiſt of twelve equal parts called penny-weights; and if the ſilver be perfectly fine, and contain no allay, then the twelve parts of the maſs are all of pure ſilver, and this ſilver is ſaid to be *ſilver of twelve penny-weights.* If the maſs of ſilver contain a twelfth part of allay, it will then contain only eleven parts of pure ſilver, and it will be called *ſilver of eleven penny-weights*, &c.

To expoſe more preciſely the value of ſilver, each penny-weight is ſubdivided into twenty four grains. (*d*)

DXXXII. PEPPER. (*e*)

(*d*) A *penny-weight* is alſo a real weight uſed in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

(*e*) PEPPER. Neuman ſays, that *Pimento*, or *Jamaica Pepper*, appears from a chemical examination to contain, 1. An indiſſoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drams and a ſcruple in an ounce. 2. Gummy or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at firſt gave two drams and two grains of gummy extract; and another ounce, freed by rectified ſpirit from all that the menſtruum could diſſolve, yielded ſtill with water five ſcruples of mucilage. 3. A reſinous ſubſtance in ſmaller quantity. The reſinous extract obtained by applying rectified ſpirit at firſt, amounted to only one dram and ſix grains from an ounce; an ounce freed from its mucilaginous matter by coction in water, yielded of pure reſin no more than one ſcruple. 4. An eſſential oil in ſtill ſmaller quantity; of this principle an ounce of pepper contains ſcarcely half a dram.

Upon examining the qualities of the ſeveral products, it appeared, that the oil is the principal and characteriſtic part, containing all the ſmell and the aromatic flavor, though not the pungency of the berry. As the prevailing flavor of pimento approaches that of cloves, the oil alſo greatly reſembles the genuine oil of cloves. It has the ſame kind of ſmell and taſte, diſcovers no great heat or pungency, and is ſo heavy as to ſink in water;

DXXXIII. PERUVIAN-BARK. (*f*)

DXXXIV. PETROLEUM. *See* BITUMEN.

DXXXV. PETUNTSE. (*g*)

DXXXV. PHLEGM. Chemiſts have given the name *Phlegm* to the moſt watery part obtained from bodies by diſtillation or otherwiſe.

Phlegm is frequently water mixed ſuperabundantly, and not combined in the bodies from which it is obtained. Such are the phlegms obtained by diſ-

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water: to which may be added, that the oil of pimento, like that of cloves, reſides chiefly in the ſhell or cortical part, the internal ſubſtance yielding little or none. 2. That the heat and pungency are lodged in the reſin. In this reſpect alſo pimento agrees with cloves: but as pimento in ſubſtance is far leſs hot and fiery than cloves, its reſin is alſo more mild. 3. That the gummy parts have very little activity.

Rectified ſpirit of wine elevates nothing from this ſpice in diſtillation, the oil of pimento being too ponderous to riſe with ſo light a fluid. The only way of making a ſpirit from it is to diſſolve ſome of the oil in pure ſpirit of wine. An agreeable ſpirituous water may be made with proof ſpirit, the watery phlegm in that liquor carrying up a part of the oil.

The *black pepper* of the Eaſt Indies contains an eſſential oil which has a ſtrong and durable ſmell, and a taſte the mildeſt of all eſſential oils. This oil is partly elevated in diſtillation by rectified ſpirit of wine; which thereby acquires the flavor, but none of the pungency, of the pepper. The ſpirituous extract is exceſſively fiery. The watery extract is alſo very hot and biting. Neither this menſtruum nor the ſpirit can, ſingly, extract all the hot matter of the pepper.

Sixteen ounces of black pepper yielded with water ten ounces of gummy extract, and afterwards with rectified ſpirit three drams of reſin: another pound, treated firſt with ſpirit, gave two ounces and two drams of reſinous extract; and afterwards, with water, ſeven ounces four drams and two ſcruples of gummy matter. This laſt extract had ſtill ſome degree of pungency, rectified ſpirit ſeeming not to take up all the active parts, any more than water. Of eſſential oil, about two drams and a half may be obtained from a pound.

White pepper has the ſame kind of taſte and flavor as the black, but in a much leſs degree. It agrees alſo with the black in the nature of its chemical principles; and is, in effect, the ſame kind of fruit gathered before it is grown fully ripe, and freed from the outer ſkin. *Neuman.*

(*f*) PERUVIAN BARK. Neuman ſays, that from a pound of Peruvian bark rectified ſpirit extracted ten drams and two ſcruples of reſinous matter; and that water extracted from the reſiduum five drams of gummy matter. He ſays alſo, that by applying water firſt, and afterwards ſpirit, to the reſiduum, ſeven drams and a ſcruple of gummy matter, and ſix drams of reſinous matter were extracted. To this Dr. Lewis adds the following note. *See* his edition of *Neuman's Works*.

"Different ſorts of Peruvian bark differ conſiderably in their yield of extract. Thoſe which I examined afforded a much larger quantity of reſinous extract than Neuman obtained from his.

"It is obſervable of this drug, ſays he, that its aſtringency reſides wholly in the reſin, which does not appear to be in any degree ſoluble in watery liquors, but its bitterneſs in a gummy-reſinous ſubſtance, or ſuch a one as is ſoluble both in water or in ſpirit. Both principles may be extracted by boiling in water, the reſin melting out by the heat, and rendering the liquor turbid. The decoction in this ſtate taſtes aſtringent as well as bitter; but on ſtanding it depoſites the reſin and becomes clear, and then proves ſimply bitter. Repeated coction and large quantities of water are neceſſary for extracting all the virtues of the bark: the reſin melts out in the firſt boilings: the decoctions made afterwards are tranſparent and bitter, without the leaſt turbidneſs or aſtringency."

(*g*) PETUNTSE. This is the Chineſe name given to a ſtone which is one of the ingredients of oriental porcelain. It is ſaid to be white, fuſible by fire, to give phoſphoric light when rubbed, and to have the other properties of the ſtones called fluors. *See* PORCELAIN.

tillation with the heat of a water-bath, from all thoſe vegetable and animal matters which contain no principle ſo volatile as to riſe with a leſs heat than that of boiling water. Theſe phlegms, which are produced merely by drying, are nothing but water almoſt pure, that is, the water of vegetation: but a phlegm conſiſting of water which had been combined in any body, as, for inſtance, the phlegm obtained in the diſtillation of oils, is far from being a pure water. It is ſtill mixed and even united with a ſenſible quantity of the principles of the body, and requires further operations, and chiefly the aſſiſtance of intermediate ſubſtances, to ſeparate it perfectly.

Neither is that phlegm pure water, which, though it is ſuperabundant, yet adheres to certain ſubſtances, eſpecially to thoſe that are volatile. Such are liquid volatile alkalis, and moſt alkalis. By diſtillation we may ſeparate a conſiderable quantity of their phlegm or ſuperabundant water, which operation is called *dephlegmation:* but this phlegm contains always a certain quantity of the ſaline matters with which it was originally mixed.

Hence we may ſee that the word *Phlegm* ſignifies in general the moſt watery part ſeparated from ſeveral bodies, but that it is rarely pure water; and that phlegms differ from each other according to the nature of the ſubſtances from which they are obtained.

DXXXVI. PHLOGISTON. By *phlogiſton* chemiſts mean the moſt pure and ſimple inflammable principle.

Amongſt the various natural bodies, ſome have been obſerved to be capable, by expoſure to fire with the concurrence of air, of being kindled, of producing flame, of augmenting the fire, and of maintaining and ſupporting it; while other bodies, by expoſure to fire, do indeed become hot, red, and luminous; but are incapable of producing flame, or of maintaining fire. Theſe latter ſubſtances do not burn, but only are penetrated by a foreign fire, and ceaſe to be hot and luminous, when this extraneous fire is removed from them.

Theſe bodies are diſtinguiſhed from each other by calling the former *combuſtible bodies*, and the latter *incombuſtible*. Chemiſts have always made a great diſtinction betwixt theſe two kinds of bodies, and have perceived that the inflammability of the former was cauſed by a principle which did not exiſt in the latter: but as this inflammable principle cannot be ſeparated from the other principles of bodies, nor be obtained pure; and, conſequently, as it is impoſſible to diſcover all the properties which are peculiar to it, and which diſtinguiſh it from all other ſubſtances, the ancient chemiſts had very confuſed notions of this inflammable principle; and even now, notwithſtanding all the ſagacity of the greateſt modern chemiſts, this is, of all the principles of bodies, the leaſt accurately known.

The great error of ancient chemiſts was, in not ſufficiently diſtinguiſhing this principle from other more compound bodies, which indeed contain much of it, but of which it is only a conſtituent part. For inſtance, they confounded it with oil and with ſulphur, the names of which ſubſtances were indiſcriminately given to it, although neither oil nor ſulphur be the phlogiſton of the moderns, but are only ſubſtances into the compoſition of which a great quantity of this principle enters.

On the other hand, as oil, ſulphur, and other inflammable matters, differ ſo much from each other that they cannot be conſidered as the ſame thing, probably the ancients, who ſometimes gave it one and ſometimes another of the names of theſe inflammable compounds, miſtook its unity and identity; that is, they did not know that one only inflammable principle exiſts, always the ſame, always ſimilar to itſelf, either in oils, or in ſulphur, or in coals, in a word, in any combuſtible whatever. We owe the knowledge of theſe important truths to modern chemiſts, and particularly to the illuſtrious Stahl, who has created in ſome meaſure a new chemiſtry, and entirely changed the appearance of this ſcience. All that we ſhall ſay concerning phlogiſton or fire as a principle of bodies ſhall be the grounds of the doctrine of that chemiſt concerning this important matter.* To that we ſhall only add ſome obſervations reſulting from an attentive examination of the phenomena.

Phlogiſton ought to be conſidered as elementary fire combined, and rendered one of the principles of combuſtible bodies.

The principal phenomena exhibited by combuſtible bodies are to kindle, to excite heat and light, to produce the ſame effects upon other bodies as are produced by the ſolar rays united in a focus, or by the friction of hard bodies. All theſe bodies may be inflamed or put into an igneous ſtate by the touch of pure fire rendered active, or, which is the ſame thing, by the contact of any body actually in the ſtate of ignition.

The combuſtion of bodies occaſions a decompoſition and ſeparation of their component principles; and the phenomena of combuſtion ſubſiſt more or leſs ſenſibly, till the fire which entered into their compoſition as a principle be entirely diſengaged, exhauſted, or diſſipated. What remains afterwards of the burnt body belongs to the claſs of incombuſtibles. Theſe phenomena leave no doubt that elementary fire enters as a principle into the compoſition of theſe bodies. *See* COMBUSTION.

Boerhaave thinks that combuſtible bodies are not changed into elementary fire during their combuſtion; becauſe, ſays he, if it were ſo, the element of fire would be infinitely encreaſed: but we may reply, that this event would not happen if this fire, thus diſengaged from bodies, be capable of entering into new combinations, and of forming new inflammable bodies; but, from the ſame reaſon that it entered into the compoſition of the firſt combuſtible bodies, it may alſo enter into new ſimilar combinations. Thus, fire continually circulates, like the other elements, which are ſometimes pure, free, diſengaged from all bodies, and capable of exhibiting all their properties, and ſometimes are combined, united with other bodies, and forming compounds in which their properties are more or leſs diſguiſed and modified by thoſe of the other principles with which they are united; and thus theſe elements paſs alternately in the continued operations of nature from one of theſe ſtates to the other.

We cannot indeed eaſily conceive how pure elementary fire, whoſe parts appear always agitated by a violent motion, and deprived of all coheſion, or of any diſpoſition to adhere in a fixed manner to the parts of other bodies (*ſee* FIRE) ſhould join, as a principle, in ſo conſtant and ſolid a manner; that is, that each of its primary integrant parts ſhould ſo ſtrongly unite and adhere to each of the primary integrant parts of any ſolid body, that it ſhould become deprived of fluidity, mobility, and of almoſt all the activity which is eſſential to it. We nevertheleſs ſee, from all the chemical phenomena, that the nature and quantity of contact of the integrant and conſtituent parts of bodies are capable of producing the moſt ſurprizing unions and combinations. Facts alſo demonſtrate, that this union of the parts of fire with other bodies really exiſts; for otherwiſe we cannot conceive the phenomena of combuſtible bodies.

The phlogiſton, then, or inflammable principle of modern chemiſts, can be nothing elſe than the pureſt and ſimpleſt fire, conſidered in its ſtate of combination, and not in that of aggregation: but we do not yet know whether pure fire be ſuſceptible of combining without any intermediate ſubſtance with all the bodies with which we find it united; or whether it cannot enter into theſe combinations, but by the aſſiſtance of an union previouſly contracted with ſome ſubſtance more diſpoſed than others to combine with it, by means of which it is then rendered capable of entering into all the compounds in which we find it. If this be the caſe, phlogiſton is not pure elementary fire, but this element previouſly combined with another, and is only a ſecondary principle. Reaſons may be given for and againſt theſe opinions, which we ſhall mention.

Firſt, we ſhall obſerve, that chemiſts have not been able to ſeparate and procure alone what they call the *inflammable principle of bodies*, although they can eaſily enough procure the other ſecondary principles. They have only been able to diſengage it from bodies by combuſtion, and then it neceſſarily reſumes the ſtate of pure and active fire, which is well known to be incoercible; or elſe it is taken from one body by means of another applied to it, with which it unites as ſoon as it quits the former. In this ſecond caſe, it is indeed ſeparated from a body without combuſtion, and without reducing it to actual fire; but it is not obtained alone and pure, ſince it only quits one combination to enter at the ſame time into another.

This difficulty, hitherto not ſurmounted, of obtaining the inflammable principle of bodies in any other ſtate than that of free and active fire, appears to us one of the ſtrongeſt reaſons for believing that phlogiſton is nothing elſe than pure fire, but deprived of its activity by the union it contracts with any ſubſtance. If this be the caſe, phlogiſton has no other properties than thoſe of pure fire; or, to ſpeak more accurately, it has no other, as phlogiſton, than thoſe which ariſe from the union of pure fire with the ſeveral ſubſtances with which it is united. Theſe properties are then peculiar to each of theſe combinations, and different according to the nature of the ſubſtances combined with fire.

However that may be, the power which chemiſts have of transferring the inflammable principle from one combination to another, with combuſtion and diſſipation, has furniſhed them with the means of making moſt important obſervations on the effects which it produces in many chemical operations, and of remarking the properties which it communicates to the ſeveral ſubſtances with which it unites. They have compared the properties of a body furniſhed with its inflammable principle, with thoſe of this ſame body when deprived of this principle. They have examined the new properties of ſubſtances with which they have been able to combine phlogiſton. By obſerving this principle in its progreſs from one combination to another, and by thus tracing it, Becher, who called it *inflammable earth*, and Stahl, who called it the *principle of inflammability* or *phlogiſton*, have been able to give us much light concerning the nature of this ſubſtance, which acts ſo powerfully in almoſt all the operations of chemiſtry

The obſervations of theſe chemiſts, and of ſome others ſince their time, have taught us ſeveral general properties of phlogiſton, which we ſhall firſt relate briefly, without endeavouring to explain them, that they all may be ſeen at once collected, and from one point of view. Beſides, theſe truths will be ſufficiently illuſtrated and proved by the particular relation of the phenomena exhibited by phlogiſton in the ſeveral experiments of chemiſtry, which we ſhall have occaſion to deſcribe.

When phlogiſton is united with an uninflammable ſubſtance, a new compound reſults, which is neither hot nor luminous; but which becomes, by that union, inflammable, and capable of producing heat and light more or leſs eaſily according to the quantity of phlogiſton united with this new compound, and according to the manner in which it is combined.

The principle of fire, by uniting with bodies naturally ſolid, does not render them fluid, but diminiſhes their hardneſs, and renders them more fuſible.

Alſo the compound formed by the union of the inflammable principle with a fixed body is rendered leſs fixed than it was before that union.

It encreaſes the abſolute gravity, and frequently the ſpecific gravity of bodies into which it enters; and in ſome caſes it renders them opake.

Subſtances which have neither ſmell nor color, acquire generally one or the other, and frequently both, by their union with the inflammable principle; and hence chemiſts have been inclined to conſider it as the principle of colors and ſmells. Some bodies indeed, which contain phlogiſton, have neither any ſenſible color or ſmell. But, firſt, we can prove, that theſe bodies contain but a very ſmall quantity of phlogiſton; and, ſecondly, we know no body which contains a large quantity of this principle, which has not more or leſs of color and of ſmell.

Although the compounds in which phlogiſton enters are often very different from each other, yet this principle is not of various kinds, but is always identically the ſame, and ſimilar to itſelf, of whatever nature the bodies may be to which it is united.

Phlogiſton is not equally diſpoſed to unite with all ſubſtances. It combines very difficultly with fluid, volatile, and light matters, ſuch as air and water: perhaps even it never unites with theſe but by means of ſome intermediate ſubſtance; on the contrary, it may be eaſily combined with ſolid, fixed, and heavy ſubſtances, as earths.

Phlogiſton frequently ſerves as an intermediate ſubſtance to unite together bodies incapable of uniting, or very difficultly without it.

We know of no direct combination of phlogiſton with either air or water, that is, we know no body compoſed ſolely of phlogiſton and air, or of phlogiſton and water. But this principle is capable of combining with compounds of which water is a principle: ſuch are oily and ſaline ſubſtances, and particularly vitriolic acid and nitrous acids.

The vitriolic acid cannot unite intimately with phlogiſton unleſs it be dry, that is, unleſs it be deprived of all water ſuperabundant to its ſaline eſſence, extremely concentrated, and contain no water but that which is a principle or conſtituent part of it. From this union an inflammable compound is formed called *ſulphur*. Vitriolic acid in this ſtate quits all bodies to unite with phlogiſton, with which it forms ſulphur; and the ſulphur is always exactly alike, from whatever body the phlogiſton has been transferred. Thus, whether an oil, reſin, fat, coal, or metal, be treated with vitriolic acid, the ſame ſulphur is formed; and ſince with the ſame acid all inflammable bodies produce the ſame compound, therefore the phlogiſton of theſe bodies, however different they may be from each other, is neceſſarily the ſame, and conſequently this principle is ſingle and identical.

The inflammability of ſulphur is cauſed by the phlogiſton it contains; but its flame is not very luminous and ardent; becauſe it contains more vitriolic acid, which is incombuſtible, than phlogiſton.

Sulphur is decompoſed by the burning of its phlogiſton, which becomes diſengaged fire, and diſſipates. The vitriolic acid alſo becomes diſengaged, pure, and capable of combining with the phlogiſton of another body to form ſulphur again, entirely ſimilar to the former.

The vitriolic acid of ſulphur is united to phlogiſton only, ſince this acid contains no ſuperabundant water, and alſo as it is demonſtrated that the combuſtible bodies treated with this acid to form ſulphur give it nothing but pure phlogiſton. We may therefore diſcover ſeveral of the properties of this principle by comparing ſulphur with pure vitriolic acid. The vitriolic acid, which has neither ſmell nor color when it is pure, forms with phlogiſton a compound poſſeſſing both theſe qualities, which are even capable of being rendered much more ſenſible in ſome circumſtances; as for example, in the combination of liver of ſulphur. In the ſecond place, although we cannot certainly know if ſulphur be more or leſs volatile than pure vitriolic acid, becauſe we cannot ever obtain this acid diſengaged, without containing at the ſame time much ſuperabundant water, even when it is in a concrete and glacial form; we have reaſon, nevertheleſs, to believe, that ſulphur is more volatile than pure vitriolic acid, and that this greater volatility it receives from the phlogiſton. This, at leaſt, is evidently indicated by the volatility of ſulphureous vitriolic acid, which is infinitely greater than that of ſimple vitriolic acid.

In the third place, although the diſengaged vitriolic acid, particularly when much concentrated, is extremely greedy of moiſture, and much more ſo when deprived of all ſuperabundant water; and although the quantity of this acid be much greater than that of phlogiſton in ſulphur; yet we ſee, nevertheleſs, that ſulphur is not ſoluble in water, which can only be attributed to its phlogiſton. This difficulty of uniting with water is common to all the other combinations in which phlogiſton is intimately and abundantly combined: for which reaſon, vitriolic acid cannot form ſulphur, unleſs it be deprived of all ſuperabundant water. This character of dryneſs, and averſion to unite with water, which the principle of fire preſerves in all its combinations, has inclined Beccher to conſider it as a principle of a *dry, earthy nature*, and to call it *inflammable earth*, thus ſignifying an oppoſition of properties to thoſe of water. We ſhall not examine now whether Beccher juſtly made this diſtinction betwixt what he called a dry and earthy quality, and the humid and aqueous quality; as water is only kept fluid and humid by being penetrated with a certain quantity of diſengaged fire, and appears, when deprived of fire, to be as dry and ſolid as the ſubſtances called earthy: but this is certain, that although water perhaps may be eſſentially as dry as fire, yet theſe two are of very different natures, and have very little diſpoſition to unite and combine intimately.

When ſulphur is decompoſed by burning, its acid greedily ſeizes moiſture, as ſoon as it is diſengaged: but as all the phlogiſton does frequently not burn, particularly when the combuſtion is ſlow, a ſmall portion of it remains ſtill united with the aqueous acid. This ſmall quantity of phlogiſton adheres very weakly to the ſulphureous acid, and eaſily ſeparates from it without fire, and merely by expoſure to air: but while it remains united, it communicates properties very different from thoſe which the acid poſſeſſes when pure. The acid is rendered much more volatile; it acquires a pungent, ſuffocating, and inſupportable ſmell; and, laſtly, its ſtrength, or its adheſion to thoſe bodies with which it is capable of uniting, is greatly diminiſhed. It is then called *volatile ſulphureous acid.*

We may obſerve, that although vitriolic acid has a great affinity with phlogiſton, the preſence of water prevents the intimate union of theſe two ſubſtances. Hence, when vitriolic acid is combined with inflammable matters, if any water be contained either in the acid or in the inflammable matter, no ſulphur, but a volatile ſulphureous acid will be formed. Sometimes indeed true ſulphur is formed even in liquors, and by the humid way; but by ſome means the vitriolic acid and the inflammable principle muſt be ſeparated from all ſuperabundant water, elſe the intimate union by which ſulphur is formed, will not happen. *See* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), SULPHUR, *and* LIVER *of* SULPHUR.

Phlogiſton has alſo a ſtrong affinity with nitrous acid, even ſtronger than with the vitriolic, as we ſhall ſee from the following facts. For, firſt, the volatility of the nitrous acid, its color, its ſmell, its inferiority of ſtrength compared with vitriolic acid; laſtly, its inflammability, and its total decompoſition by inflammation, prove, that phlogiſton enters into the compoſition of this acid, and is one of its conſtituent parts. Stahl and moſt chemiſts think, and with much probability, that nitrous acid differs only from the vitriolic by its containing phlogiſton.

In the ſecond place, nitrous acid acts more ſtrongly in general than vitriolic acid upon all compounds which contain the inflammable principle, and deprives them more effectually of this principle, as is peculiarly obſervable in ſolutions of metals. Beſides, nitrous acid ſeems to act nearly as vitriolic acid does with regard to its combinations with a quantity of phlogiſton ſuperabundant to its compoſition; but ſome differences may be perceived, which ought to be attributed to the inflammable principle which makes part of its combination. Like the vitriolic acid, it cannot unite with phlogiſton in the moſt intimate manner, unleſs it be in a dry ſtate: it then forms a kind of ſulphur which may be called *nitrous ſulphur*, which, from the phlogiſton already contained in the acid, is ſo inflammable, that it kindles as ſoon as it is formed, and therefore has never been obtained alone and uninflamed, as we obtain the vitriolic ſulphur. *See upon this ſubject* DETONATION *of* NITRE.

When the nitrous acid contains ſuperabundant water, it ſtill acts very powerfully upon the phlogiſton of moſt bodies; but no inflammation happens, excepting that during the act of combination, the phlogiſton and acid can be rendered dry; without which circumſtance, only a ſuperficial and weak union of theſe two ſubſtances can be made. The aqueous nitrous acid does indeed attract phlogiſton ſuperabundantly, by which its color, ſmell, and volatility, are conſiderably encreaſed; of which we ſee very evident examples in the ſolutions of almoſt all metallic matters by this acid, as of iron, zinc, copper, tin, &c. But then this phlogiſton adheres but weakly to the acid, becauſe of the water of the acid, as it does, for the ſame reaſon, to the volatile ſulphureous acid; and it ſeparates, without heat, by mere expoſure to air.

Although nitrous acid be probably capable of thus attracting ſuperabundantly a larger quantity of phlogiſton than vitriolic acid, we do not obſerve, nevertheleſs, that this ſuperabundant phlogiſton produces ſuch a change upon the nitrous acid, as it does upon the pure vitriolic, when it converts this latter into the volatile ſulphureous acid. The cauſe of this evidently is, that nitrous acid in its natural ſtate contains already ſo conſiderable a quantity of phlogiſton as one of its principles, that it has in a certain degree all the properties of a phlogiſticated acid; and theſe qualities ought not to be changed, but only rendered more ſenſible by the addition of a ſuperabundant quantity of phlogiſton: whereas the vitriolic acid in its pure ſtate, not containing any phlogiſton, or at leaſt not ſenſibly, muſt, by ſuch an addition, paſs from the ſtate of an unphlogiſticated acid to that of an acid united with the inflammable principle, when from a pure vitriolic acid it becomes a volatile ſulphureous acid, by which it is rendered entirely different. This ſeems to me to be one of the beſt proofs that nitrous acid contains phlogiſton as a principle and conſtituent part. *See* Acid (Nitrous).

As the acid of common ſalt has ſmell, color, and particularly much volatility, it ſeems provided with all the properties of an acid united with the inflammable principle. Nevertheleſs, we do not ſee that it has the ſame diſpoſition as the vitriolic and nitrous acids to combine itſelf with this principle, neither intimately, nor even ſuperficially. On the contrary, it is incapable of acting upon many inflammable matters, for inſtance, oils; it acts more weakly upon metals, deprives them of leſs of their inflammable principle, and adheres to them more ſtrongly than the other two mineral acids. Laſtly, we do not know any immediate combination of marine acid with phlogiſton, that is, any *marine ſulphur*; for the phoſphorus of Kunckel, which has been believed to be ſuch by Stahl and other chemiſts, is not a marine ſulphur, as we ſhall ſee in its place. From what cauſe then do properties ſo contradictory proceed? We know too little of the true nature of the marine acid, and of the principle which diſtinguiſhes it from the other acids, to be capable of ſaying any thing ſatisfactory upon this ſubject. According to Becher, the mercurial earth diſtinguiſhes this acid from the others. If this be true, the union of phlogiſton with marine acid is prevented by this earth. But, on the other ſide, this earth appears to have many of the properties of phlogiſton, both from the properties of marine acid, and from thoſe of metals, which alſo are ſuppoſed to contain mercurial earth: or, is not this union of phlogiſton with marine acid prevented by a certain modification of the phlogiſton itſelf contained in that acid, by which its nature is in ſome meaſure changed, as Henckel ſeems inclined to think? Let us hope for further illuſtration of this obſcure matter from time, experience, and the advancement of chemiſtry. *See* Acid (Marine).

Fixed alkalis ſhew in many experiments a conſiderable diſpoſition to unite with phlogiſton. Their properties ſhew even that this principle is one of their conſtituent parts; nevertheleſs, they ſeem to have leſs affinity with phlogiſton

giſton than the vitriolic and nitrous acids, or even than metallic earths. The phenomena exhibited by them when united with inflammable matter have not been ſufficiently examined. In ſome caſes, they acquire a very quick and pungent ſmell, and extreme volatility, as when they are changed into volatile alkali; which happens, as is known, by combining and diſtilling them with fat matters. In other caſes, they may be ſaturated with an inflammable matter, with which they appear to be intimately united, although they do not acquire the ſmell and volatility of *volatile alkali*. This happens when they are calcined in cloſe veſſels with coals, as in the preparation of the ſaponaceous alkali for the Pruſſian blue. Are theſe two combinations of alkali with phlogiſton any thing ſimilar to the combinations of the vitriolic and nitrous acids with the ſame principle? I am inclined to believe ſo; but this matter requires further examination. *See* ALKALI (FIXED).

Phlogiſton then appears to have a ſtrong diſpoſition to unite with dry and earthy matters, and to adhere to them ſtrongly: but notwithſtanding this diſpoſition, we cannot make this combination with any given proportions of theſe matters, nor with any of the ſubſtances containing phlogiſton. I do not know that phlogiſton would quit the vitriolic acid or metals to unite with a ſimple earth: we have no reaſon to preſume that this could be effected, unleſs perhaps by very nice and difficult proceſſes. This is certain, that although theſe reſearches be very intereſting, as they are connected with the theory of the compoſition of metals which ſeem to be formed of earth and phlogiſton, they have not been ever made; or, at leaſt, the attempts of chemiſts upon this ſubject have not been diſtinctly publiſhed. *See* METALS *and* METALLIZATION.

Several kinds of earths, particularly thoſe the parts of which are naturally very fine and much divided, ſuch as calcareous, and more eſpecially argillaceous earths, appear the fitteſt to be united with the inflammable principle; and further, phlogiſton ſeems to be moſt diſpoſed to unite with theſe earths when it is in the ſtate of oil, of ſoot, or of vapors. Accordingly, when calcareous or argillaceous earths have been mixed with fat matters, and have afterwards been expoſed to the action of fire in cloſe veſſels, they retain much of the phlogiſton of theſe matters, which adheres ſtrongly, and communicates color to them, particularly ſhades of blackneſs, which cannot afterwards be ſeparated but by a very long calcination in an open fire. In Mr. Macquer's Memoir upon Clays, we may ſee, that when theſe earths are expoſed to violent fire, although many of them be naturally white, and others become white by a moderate heat, they all acquire colors when expoſed to violent fire, apparently from contact of phlogiſtic vapors; and that theſe colors, which are black, grey, yellow, greeniſh or bluiſh, remain obſtinately without any poſſibility of deſtroying them. *See* CLAYS.

The coals of vegetable and animal matters are nothing elſe than ſingular combinations of the earthy part of theſe organiſed bodies with the inflammable principle of their oils and fat. All the properties of coals ſhew us, that although their phlogiſton be in a very combuſtible ſtate, it nevertheleſs adheres to them in a very fixed manner, ſince they can ſupport the moſt violent fire in cloſe veſſels without the leaſt alteration, or loſs of any part of their inflammable principle.

This principle, however, is not ſo adherent to the earth of coals, that it cannot quit it to combine with other ſubſtances, with which it has a ſtronger affinity; for inſtance, with the vitriolic, nitrous and phoſphoric acids, and with metallic earths. Accordingly, coals by expoſure to a violent fire in cloſe veſſels together with any of theſe ſubſtances, are decompoſed, their phlogiſton is ſeparated and combined with the ſubſtance applied to it, with which it forms a new inflammable compound; common ſulphur, for inſtance, with vitriolic acid; nitrous ſulphur with nitrous acid; phoſphorus with phoſphoric acid; and, laſtly, metals, with metallic earths: coal is therefore one of the fitteſt inflammable ſubſtances for tranſmitting phlogiſton to other matters, and therefore is much employed for that purpoſe in chemical operations. *See* Coal.

The properties of phlogiſton are particularly evident and diſtinct in metallic matters. The decompoſition and recompoſition of all imperfect metals and ſemimetals, by the ſubſtraction and reſtitution of the inflammable principle, leaves no doubt that this principle is one of their eſſential conſtituent parts. This is a chemical truth, which may be conſidered as demonſtrated.

We may ſeparate phlogiſton from metallic matters by the general method by which it may be ſeparated from all combuſtible bodies, that is, by combuſtion in open air; for without this condition, the phlogiſton of metals, even the moſt combuſtible, is no more capable of burning in cloſe veſſels than that of coals. *See* Calcination, Calx (Metallic), *and* Combustion.

All mineral acids, and even the combined action of water and of air, are capable of depriving metals of their phlogiſton, which is then done without any combuſtion.

Metals calcined, reduced to calxes or earths by ſome of theſe methods, or rather metallic earths, are capable of combining again with phlogiſton, and of reſuming all the metallic properties by ſeveral methods; that is, by fuſion with coal, or other inflammable matters which are converted into coal during the operation. This is the ordinary method of reducing or recompoſing metals. *See* Reduction. Metallic earths may alſo recover their phlogiſton, by applying this principle in the ſtate of vapors, or even by the humid way, by treating them with liver of ſulphur, oils, &c. But the phlogiſton of metals ſeems to be nevertheleſs in a dry ſtate, as well as the phlogiſton of ſulphurs and of coals, as all the properties of metals ſhew. Thus if their earths are capable of recombining with the inflammable principle, even by the humid way in certain circumſtances, the humid combination of phlogiſton muſt be itſelf decompoſed on theſe occaſions, and this principle muſt be ſeparated from all moiſture to combine, at leaſt in an intimate manner, with metallic calxes, and to reduce them into true metals. This reduction is ſimilar to the production of ſulphur in the humid way. *See* Reduction *and* Sulphur.

As the calcination and reduction of metals are performed by the ſeparation and reſtitution of the inflammable principle alone, we may, by comparing the properties of metals with thoſe of their calxes, obtain demonſtrative proofs of many of the eſſential properties of phlogiſton, which we have mentioned in the beginning of this article.

Metallic calxes are generally harder, more ſolid, more fixed, leſs denſe, leſs fuſible, leſs opake than the metals. All theſe qualities then, more or leſs eminent in metals, proceed from phlogiſton. Further, the earths of metals, by loſing their phlogiſton, loſe alſo their ſolubility in acids: hence phlogiſton is an intermediate ſubſtance by which metals are diſſolved in acids, from the great affinity which it has with theſe ſolvents. We ſhall now mention ſome particular inſtances of what we have here advanced in general.

Lead and tin are very ſoft metals; nevertheleſs, when lead is calcined and afterwards melted, a glaſs is formed much harder than the lead from which it was produced. Tin, which calcines ſtill more compleatly than lead, is eaſily changeable into a white earth, the parts of which, though very fine, are ſo hard, that they are employed to poliſh very hard bodies, as ſteel, glaſs, &c.

The moſt volatile ſemimetals, as regulus of antimony and zinc, are changed by burning their phlogiſton into perfectly fixed earths.

Regulus of antimony and tin are fuſible with a gentle heat; yet the calxes of theſe metals are juſtly conſidered amongſt the moſt refractory bodies.

The denſity, opacity, and ductility which metals receive from their phlogiſton evidently proceed from the particular manner in which the parts of the phlogiſton are applied to thoſe of the metallic earths. Theſe properties ſeem to ſhew that the primary integrant parts of phlogiſton, although perhaps the ſmalleſt of all imaginable atoms, are eſſentially very denſe and very opake; and alſo, that to give theſe qualities ſo eminently to metals, they muſt be capable of filling very accurately the ſmall interſtices betwixt the primary integrant parts of the metallic earths. The laſt mentioned properties of phlogiſton ſeem to favour the opinion of Beccher and Stahl, who conſider it as an earthy ſubſtance, the parts of which are exceedingly ſmall, not, or but little, coherent to each other, and fitter than any other ſubſtance to acquire the rapid motion in which conſiſt all the effects of fire; or rather, it is the only ſubſtance capable of receiving the igneous motion. *See* METALS *and* METALLISATION.

Although phlogiſton ſhews, in all chemical experiments, a ſtrong repugnancy againſt uniting with water, and even with any ſubſtances containing water, we, nevertheleſs, find it combined with this principle in oils, reſins, and in all vegetable and animal inflammable ſubſtances. We cannot doubt that theſe matters contain water; for it is obtained in their analyſis, and alſo their inflammability ſufficiently proves that phlogiſton is one of their conſtituent parts. Hence we find, that theſe two ſubſtances may aſſiſt in the compoſition of one body: but probably they are not united together immediately in oily compounds, but by means of an earth or rather of an acid; for we know that phlogiſton unites much more readily with earths and acids than with water; and alſo, that earths and acids are obtained in the analyſis of all oily ſubſtances.

As then oils are much more compounded than ſulphurs, metals, and coals, the phenomena exhibited by phlogiſton in oily matters are different from thoſe in theſe other inflammable bodies. Phlogiſton adheres leſs to oily matters, and is more readily combuſtible, and alſo when it is diſengaged by inflammation it is always accompanied with ſome of the other principles of the oily matter which it carries along with it, that is, of the water, acid, and earth which compoſe this matter; all which together form an oily flame. In this combuſtion even all the phlogiſton is not diſſipated: one part of it attaches itſelf much more intimately with the earth of the oil, and forms with this earth a matter black, very fixed, and much leſs combuſtible than oil, called *lamp-black* or *ſoot*. It is a kind of coal, and is conſidered by Stahl as almoſt pure phlogiſton.

This fuliginous quality by which oils differ from other inflammable matters, is in a greater or leſs degree, according to the nature of oils, and the greater or leſs activity with which they burn; in general, the more quickly and ſtrongly they burn, the leſs fuliginous matter is formed; ſo that perhaps if an oil was reduced altogether to vapors, it might be burnt in an inſtant without forming any fuliginous matter.

When oils are decompoſed without combuſtion, and by diſtillation, ſomething ſimilar happens. The phlogiſton of the decompoſed part of the oil attaches itſelf to the fixed and earthy part of the oil, intimately unites with it, and forms a coal. In this manner are all coals made.

Oil can tranſmit phlogiſton to all the ſubſtances capable of uniting with it: but in the formation of intimate combinations, as thoſe of ſulphur and metals, the water muſt neceſſarily be ſeparated from the oil. The ſame alſo is obſervable of ſoot and coal, although theſe ſubſtances have been produced from oil itſelf; yet their phlogiſton is never in a ſtate of perfect combination, unleſs they be quite dry. *See* Oils *and* Coal.

Ardent ſpirit and the *ſpiritus rector* of vegetable and animal ſubſtances are alſo compounds in which are contained both phlogiſton and water; for theſe ſubſtances are, at the ſame time, very inflammable and miſcible with water. Beſides, water is obtained in their decompoſition. The phlogiſton of theſe ſubſtances is, nevertheleſs, in a very different ſtate from that of oils; for their flame is leſs luminous, and is not accompanied with any ſoot. The cauſe of this difference probably is, that phlogiſton is more immediately united with water in theſe ſpirits than in oils. Some chemiſts even imagine, that in ardent ſpirits phlogiſton is united to water without any intermediate ſubſtance. The acid is certainly in leſs quantity and leſs ſenſible in ſpirituous inflammable liquors than in oils properly ſo called; and alſo theſe ſpirits may be approximated to the nature of oils, or even changed into true oils, by treating them with acids. *See* Oils Spirit (Ardent), Spiritus Rector, *and* Ether.

From theſe properties of phlogiſton it appears, that it is a principle dry, volatile, ſuſceptible of the igneous motion, capable of combining with primary principles, as earth and water, but much more difficultly with this latter; that it is a component part of many bodies, to which it communicates an inflammable quality; that it is capable of paſſing from one combination to another; and that it is identical, or the ſame in all compounds, as the other principles are. Stahl thinks, that phlogiſton is not elaſtic; and indeed moſt inflammable vapors, in which this principle ſeems to be almoſt pure, are not elaſtic: on the contrary, they deſtroy the elaſticity of the air.

Hitherto the inflammable principle has never been obtained pure and ſingle; and if it be nothing elſe than the matter of elementary fire, we evidently can never obtain it otherwiſe than as we have done; that is, in active and burning fire, by collecting the ſolar rays, &c. Nevertheleſs, in many occaſions phlogiſton diſcovers itſelf without inflammation, if not abſolutely pure and ſimple, at leaſt conſiderably ſo. Stahl believes, as we have already ſaid, that ſoot is almoſt pure phlogiſton. This matter does indeed ſeem to be one of the ſimpleſt combuſtible matters: but its great fixity and ſmall degree of combuſtibility

buſtibility prove that in this ſubſtance the phlogiſton is intimately united with a conſiderable quantity of very fixed earthy matter, which is capable of diſguiſing many of its eſſential properties. I believe therefore, that we may conſider the very volatile, not inflamed vapors riſing from ſeveral combuſtible bodies on certain occaſions, as phlogiſton ſtill more ſimple, more copious, and more diſengaged. Such, for inſtance, are the vapors of ſulphur formed into liver of ſulphur, particularly when it is precipitated by an acid, or expoſed when dry to a gentle heat, incapable of kindling ſulphur: ſuch alſo are the vapors of coals of all kinds when they burn weakly and ſlowly, becauſe then a conſiderable quantity of the inflammable principle of theſe coals is exhaled without being inflamed. The ſubtile vapors diſengaged from matters undergoing the ſpirituous and putrid fermentations, the vapors of mines and ſubterranean places, called *damps*, appear alſo to be of the ſame kind. All theſe vapors are ſimilar in this reſpect, that when they are not at liberty to diſſipate themſelves in open air, they have the property of abſorbing air, or of deſtroying its elaſticity, and of acting ſuddenly upon the brain and nervous ſyſtem of men and animals, whom they affect with drunkenneſs, ſtupefaction, ſuffocation, ſyncope, and death. Theſe exhalations are all ſuſceptible of being inſtantly inflamed, and with more or leſs exploſion, according to circumſtances, when they are accumulated and confined in a place, and a lighted ſubſtance applied to them. Theſe vapors then are conſiderably analogous. They all proceed from bodies abounding in inflammable principles, and are themſelves inflammable: laſtly, when they are applied to any body capable of combining eaſily with phlogiſton, ſuch as, for inſtance, metallic calxes not much dephlogiſticated, they very quickly and eaſily adhere to it. We ſeem then to have reaſon to preſume, after all theſe facts, that theſe emanations are nothing but the inflammable principle, almoſt pure, and which is but weakly connected with ſome other principle.

Such are the chief properties of this principle, the knowledge of which has become ſo important and eſſential ſince the diſcoveries of Beecher, Stahl, Geoffroy, and other modern chemiſts.

DXXXVII. PHOSPHORUS (ENGLISH), *or* **KUNCKEL's PHOSPHORUS.** The name *phoſphorus* is applied to all ſubſtances capable of giving light in the dark; ſuch as glow-worms, rotten-wood, diamonds after having been expoſed to the ſun or light, the Bolognian ſtone, and certain ſpars after calcination. The effects of theſe phoſphoric matters proceed from electricity, or ſome property of light. We ſhall mention theſe in the following article. The phoſphorus we now treat of is of a very different nature. It is a ſubſtance not only luminous in the dark, but alſo inflammable and burning. It is a combination of phlogiſton with a peculiar acid, and is conſequently a ſpecies of ſulphur.

The diſcovery of this phoſphorus is not very ancient: it was diſcovered by a citizen of Hambourg, called Brandt, in his reſearches for the philoſopher's ſtone. Kunckel was deſirous to acquire this ſecret, and for this purpoſe aſſociated himſelf with one of his friends, called *Kraaft*, who thinking by means of it to make a fortune, reſolved, after having procured it, not to reveal it, and even obtained a promiſe from the inventor not to communicate it to Kunckel.

Kunckel, vexed by this treachery, reſolved to ſearch for the phoſphorus: and although he knew no more of the proceſs than that urine was the ſubſtance employed, he proſecuted this inquiry with ſuch zeal, that at length he made phoſphorus. This chemiſt took to himſelf very juſtly the honor of having diſcovered it, and was accordingly conſidered as one of the diſcoverers of it, with ſo much more reaſon, as he did not find it by chance, and without ſearching for it, as Brandt had done, but after a rational inquiry undertaken for this purpoſe. Accordingly Kunckel's name is affixed to this phoſphorus, which is commonly called the *phoſphorus of Kunckel.*

The celebrated Mr. Boyle has alſo had the reputation of having made this diſcovery. Thoſe who give him the credit of this, ſay, that Boyle having ſeen a bit of phoſphorus in England in 1679, which Kraaft had brought thither to ſhew to the King and Queen of England, and having been informed only that this phoſphorus was produced from ſome matter belonging to the human body, attempted, like Kunckel, to diſcover the method of preparing it, and in the following year actually made a ſmall quantity, which he lodged with the ſecretary of the Royal Society, who gave him a receipt for it. But Stahl, in a ſmall work called the *three hundred experiments*, ſays that Kraaft told him that he communicated the proceſs to Mr. Boyle. If this be true, Boyle has claimed the honor of a diſcovery to which he had no right, an imputation injurious to the reputation of a man ſo juſtly famous. But we muſt acknowledge, that the truth of this imputation is very queſtionable. For Kraaft, who, as Stahl relates, was ignorant of chemiſtry, who had been treacherous to Kunckel, was nothing in all this affair of phoſphorus, but a trader in ſecrets. For having purchaſed the ſecret of preparing phoſphorus, he ſold it again every where, and therefore no credit is to be given to the teſtimony of ſuch a man. However that may be, Boyle communicated the proceſs for making phoſphorus to a German chemiſt called Godfreid Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only perſons who made any conſiderable quantity of it, and the latter made a lucrative trade of it. Stahl ſays, that he knew alſo this Mr. Hantkwitz, and conſidered him as a good practical chemiſt, and that he had an excellent laboratory in London.

Proceſſes for making phoſphorus were frequently publiſhed about that time. Mr. Hellot, in his Memoir upon this ſubject, enumerates all that were then known, namely, the proceſs publiſhed by Boyle in 1680, in the Philoſophical Tranſactions, No. 196; that of Kraaft; for, after ſelling the ſecret to many perſons, he afterwards publiſhed it, in a treatiſe concerning phoſphorus written by the Abbé de Commieres, publiſhed in the Mercure Galant for June 1683; that of Brandt, in a Collection of Experiments and Obſervations of Dr. Hook, publiſhed by Mr. Derham in 1726; that of Mr. Homberg, in the Ancient Memoirs of the Academy in 1692, who ſays that he had ſeen Kunckel make phoſphorus; and, laſtly, the proceſſes found in the works of ſeveral chemiſts, particularly of Theickmeyer, Hoffman, and Neewentuit.

But notwithſtanding all theſe proceſſes, whether they were not ſufficiently compleat, or too laborious and expenſive, no chemiſt, excepting Hantkwitz, made phoſphorus, and the operation ſtill continued a ſecret till the year 1737, when a ſtranger came into France, who offered to make phoſphorus. The miniſtry granted him a reward for his proceſs, which he accordingly communicated.

municated. Meſſrs. Hellot, Dufay, Geoffroy, and Duhamel, all experimental philoſophers and chemiſts of the Academy of Sciences, executed this proceſs ſucceſsfully. Mr. Hellot wrote a diſtinct account of it, and publiſhed it amongſt the Memoirs of the Academy of Sciences for the year 1737; a large extract of which may be found in the Elements of Practical Chemiſtry.

Since the publication of the memoir of Mr. Hellot, the proceſs of phoſphorus has been no longer a ſecret. But as this operation has hitherto been rather curious than uſeful, and is alſo expenſive and troubleſome, I do not know that any French chemiſt repeated it at that time, excepting Mr. Rouelle, who ſoon afterwards began a courſe of chemiſtry, in which he undertook to make phoſphorus in preſence of his pupils. I was then preſent as one of theſe, and Mr. Hellot attended during the whole operation. We continued there the whole night; but from a fault in the retort, this firſt operation failed. However, in the years following Mr. Rouelle ſucceeded many times.

Laſtly, in 1743, that intelligent chemiſt Mr. Margraaf, who had ſeveral years been employed in making experiments upon phoſphorus, publiſhed in the Memoirs of the Academy at Berlin a new and excellent proceſs for obtaining more eaſily and expeditiouſly, and at leſs expence than has been done hitherto, a conſiderable quantity of phoſphorus. This proceſs is repeated ſucceſsfully every year by Mr. Beaumé in the courſes of chemiſtry which he gives with Mr. Macquer.

To make phoſphorus by Mr. Margraaf's proceſs, a kind of plumbum corneum is previouſly prepared, by diſtilling a mixture of four pounds of minium with two pounds of powdered ſal ammoniac, from which all the volatile alkali, which is very penetrating, is by this operation obtained. The reſiduum after the diſtillation, that is, the plumbum corneum, is to be mixed with nine or ten pounds of extract of urine boiled to the conſiſtence of honey. Mr. Margraaf requires that this urine ſhould be putrified, which is unneceſſary, according to Mr. Beaumé's obſervation. This mixture is to be made ſlowly in an iron caldron ſet upon the fire, and by frequently ſtirring the matters. Half a pound of powdered charcoal is then to be added, and evaporation is to be continued till the whole is reduced into a black powder. This powder is to be put into a retort, to extract from it, by a moderate and graduated heat, all the volatile products of urine, that is, volatile alkali, fetid oil, and an ammoniacal matter which adheres to the neck of the retort. In this diſtillation the heat is to be only raiſed ſo as to make the matter red-hot. After the diſtillation a black and friable reſiduum remains, from which the phoſphorus is to be extracted by a ſecond diſtillation, and a ſtronger heat. Before it is expoſed to another diſtillation, it may be tried by throwing ſome of it upon hot coals. If the matter has been well prepared, a ſmell of garlic exhales from it, and a blue phoſphorical flame is ſeen, undulating along the ſurface of the hot coals.

This matter is to be put into a good earthen retort capable of ſuſtaining a violent fire. Mr. Margraaf recommends retorts of *Waldenbourgh*, or thoſe which are made near *Kirchan* in Saxony; which not being known in France, we uſe Heſſian retorts, although they have the inconvenience of allowing a large quantity of phoſphorus to tranſpire during the operation. Mr. Beaumé ſecures his retorts with a covering of clay and hair.

Three quarters of the retort are to be filled with the matter which is to yield the phoſphorus. It is to be placed in the common furnace for diſtillation with a retort; excepting that inſtead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to ſix inches, according to the ſize of the furnace, and the height from eight to nine feet. This apparatus, which Mr. Beaumé uſes, is neceſſary for raiſing a ſufficient heat, and for the conveniency of throwing in a ſufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate ſize, pierced with a ſmall hole, and half full of water. For this purpoſe ordinary fat lute may be bound on with ſtrips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort paſſes ought to be well ſtopped with furnace earth. Laſtly, a ſmall wall of bricks is raiſed betwixt the furnace and receiver, to guard this veſſel againſt heat as much as is poſſible.

All theſe preparations being made the evening before the diſtillation is to be performed, we are then capable of proceeding to this operation, which is very eaſy. The retort is to be heated by ſlow degrees during an hour and a half; and then the heat is to be encreaſed till the retort be red-hot, and the phoſphorus begin to paſs in luminous vapors: when the retort is almoſt of a white red heat, the phoſphorus paſſes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more paſſes into the receiver. When a retort contains eight pints or more, this operation continues about five hours.

Mr. Margraaf's apparatus is ſomewhat different from that above deſcribed. He divides the whole quantity of matter from which the phoſphorus is to be obtained into ſix ſmall retorts, which he places in a furnace that he deſcribes. The advantage of this diviſion is, that it any accident happens to one retort, the whole matter is not loſt; and as the retorts are ſmaller, a leſs heat is required. If indeed much phoſphorus was to be made, this practice would be ſafe and excellent; but I can affirm, that the method above deſcribed of Mr. Beaumé is very convenient when a large quantity of phoſphorus is not wanted, and that I have never ſeen it fail.

Phoſphorus does not paſs pure in this diſtillation, but is blackened by ſoot or coal, which it carries along with it: It may be eaſily purified and rendered white and fine by a ſecond diſtillation or rectification. This rectification is made in a ſmall glaſs retort, to which is adjuſted a ſmall receiver half full of water. A very gentle heat is ſufficient, becauſe phoſphorus once formed is very volatile: and as the fuliginous matters with which it is ſoiled were raiſed merely by the violence of the heat, they remain at the bottom of the retort in this diſtillation; and the phoſphorus paſſes very pure.

The phoſphorus is then uſually divided into ſmall cylindrical rolls, for the conveniency of uſing it. This is done by putting it in glaſs tubes immerſed in warm water. This very gentle heat is ſufficient to liquefy the phoſphorus, which is almoſt as fuſible as ſuet. It takes the form of the glaſs tubes, from which it may be taken out when it is cold and hardened. That it may be more eaſily taken out of the tubes, theſe muſt be ſomewhat of the form of fruſtums of cones. All theſe operations ought to be made under water, to prevent the inflammation of the phoſphorus.

The proceſs publiſhed by Mr. Hellot for the preparation of phoſphorus is only different from this in two reſpects; firſt, that his is only one operation, and not divided into two, as Mr. Margraaf's is; and, ſecondly, that he does not uſe plumbum corneum. The operation is certainly much facilitated by Mr. Margraaf's method of ſeparating the volatile matters of the urine by a previous diſtillation; becauſe after that, nothing more is requiſite but to apply heat ſufficient to raiſe the phoſphorus; which may be done in four or five hours; whereas without this previous operation, the diſtillation laſts twenty-four hours. We are not ſo certain concerning the advantage of adding plumbum corneum, or whether it might not be omitted; for, as this addition does not much encreaſe the trouble of the operation, chemiſts who have hitherto made phoſphorus by Mr. Margraaf's proceſs have followed it in every point, without making any experiments to determine the neceſſity of this addition.

Phoſphorus is a kind of ſulphur compoſed of a peculiar acid united with phlogiſton. This matter is extremely fuſible, as we have ſeen. It has, like ſulphur, two kinds of inflammation; one very weak, emitting a flame not powerful enough to kindle other combuſtible matters, but ſufficient for the gradual conſumption and burning of its own phlogiſton; the other is vivid, brilliant, and ſtrong, accompanied with decrepitation, and capable of kindling inſtantly any combuſtible matter. Theſe two flames of phoſphorus are eaſily diſtinguiſhable during the diſtillation of it, when the ſmall hole of the receiver is unſtopped; for when the veſſels are not too much heated, the flame which iſſues through the hole is luminous in the dark, but does not kindle any combuſtible matter; it may be touched without danger, and it only renders the hands that touch it luminous. But when the veſſels are too much heated, the flame iſſues with more force; it then decrepitates, and is capable of burning any perſon that touches it. This flame is a ſign that the heat is too ſtrong; and therefore when it is perceived, the fire ought to be leſſened.

Phoſphorus reſembles vitriolic ſulphur alſo in this point, that all its phlogiſton may be burnt, even with rapidity, without any decompoſition of its acid.

But it differs from ſulphur in being much more combuſtible. In this circumſtance it ſeems to be in a middle ſtate betwixt the vitriolic and nitrous ſulphurs. A heat from twelve to fifteen degrees is ſufficient to decompoſe phoſphorus, and to make its phlogiſton burn, weakly and ſlowly indeed, but with a ſenſible light, particularly in open air. To prevent this decompoſition, it muſt be preſerved under water; and even in water it is partly decompoſed, and it fills the containing bottle with luminous vapors; its ſurface loſes its ſemi-tranſparency, and becomes farinaceous; and the water becomes more and more acid.

When phoſphorus is heated by fire, or by friction, it then violently inflames, burns fiercely, and emits many vapors, as ſulphur does; which however differ from thoſe of ſulphur in ſmell, which is like that of garlic or arſenic; and alſo in being always viſible, as a white ſmoke during day, and as a light, when in the dark.

Phoſphorus does not ſeem to be ſo ſtrongly diſpoſed as ſulphur is to unite with metals. Mr. Margraaf has tried to make this combination with all metals and ſemi-metals. For which purpoſe he took ſome filings of each metallic ſubſtance, digeſted it with two parts of phoſphorus, and diſtilled the mixtures. In all theſe experiments part of the phoſphorus paſſed into the receiver, as when it is rectified; the other part was burnt, and the metals remained untouched, excepting copper and zinc, which were acted upon in the following manners.

Copper treated by Mr. Margraaf with phoſphorus loſt its metallic brilliancy, and became more compact; a gros or 72 grains of copper being twice treated in this manner with phoſphorus, was found to have acquired ten grains in weight, and to be rendered capable of being kindled when expoſed to flame.

Zinc treated twice with phoſphorus in the ſame manner, and expoſed to ſtrong heat at the end of the ſecond diſtillation, was ſublimed almoſt entirely in form of light pointed flowers of a reddiſh-yellow color, which being put under a muffle, were inflamed and vitrified, forming a tranſparent glaſs like that of borax. From theſe experiments we ſee that phoſphorus has little diſpoſition to unite with metals, which property perhaps proceeds from the facility with which it is decompoſed.

According to the experiments of the ſame Mr. Margraaf, phoſphorus ſublimes with arſenic into a compound of a ſhining red color, in which reſpect it reſembles common ſulphur. It eaſily unites with ſulphur. Equal parts of theſe two matters being mixed together and diſtilled, paſſed into the water of the receiver, congealed there, forming a ſubſtance which when rubbed by the fingers, could not eaſily be inflamed, but gave a yellow light, and readily kindled when expoſed to a heat nearly equal to that of boiling water. Mr. Margraaf ſays, that this compound had a fœtid ſmell, like that of liver of ſulphur; and that it ſwelled in water, to which it gave a ſulphureous ſmell, and manifeſt acidity; which effects prove a decompoſition of theſe ſubſtances.

Mr. Margraaf treated phoſphorus alſo with the three mineral acids by diſtilling them together in a retort; and theſe experiments furniſhed very curious obſervations. Vitriolic acid decompoſed almoſt entirely phoſphorus, but without any inflammation. Nitrous acid attacked it with violence, even without the help of fire, and occaſioned a ſudden inflammation, with exploſion and rupture of the veſſels. Laſtly, marine acid produced no alteration upon phoſphorus, nor was itſelf altered. Theſe phenomena are perfectly analogous to the affinities of the three mineral acids with the inflammable principle.

Phoſphorus is ſoluble in oils and inflammable liquors, nearly as ſulphur is, and conſequently forms *balſams of phoſphorus*. But when combined with theſe ſubſtances, it ſeems to be more diſpoſed to decompoſe, than when it is alone; for theſe oily phoſphoric liquors are always luminous, particularly when they are heated a little, and are expoſed to air.

But phoſphorus differs eſſentially from ſulphur by the nature of its acid, which is not yet well known by chemiſts. They believed a long time that it was the ſame as marine acid. Stahl was of this opinion, and others received it. That great chemiſt, in other reſpects ſo accurate and ſo much to be credited, was induced to this opinion by conſidering that urine contains much common ſalt, and that common ſalt expoſed to contact of burning fuel is reduced to flowers, makes the coals burn more intenſely, and occaſions a flame ſimilar to that of phoſphorus. We have reaſon to wonder that ſuch a chemiſt as Stahl ſhould pronounce concerning the nature of this acid from ſo ſlight reaſons, when we conſider that the properties of the phoſphoric are ſo very different from thoſe of the marine acid. But we ſhall be more ſurpriſed to find that he poſitively affirms, in his book called *Three Hundred Experiments*, that to make phoſphorus, nothing more is requiſite, but to mix and combine properly marine acid with phlogiſton; and that by proſecuting what he had publiſhed concerning the artificial compoſition of ſulphur, we may make phoſphorus as abundantly and eaſily as ſulphur itſelf.

We cannot wonder that chemiſts, truſting to ſo great an authority, ſhou'd have firmly believed that the acid of phoſphorus was the ſame as marine acid. Accordingly when Mr. Margraaf undertook to ſimplify and improve the proceſs for phoſphorus, he made many experiments to combine marine acid directly with phlogiſton. We ſee in his memoirs, that he made theſe trials not only by employing common ſalt, but alſo ſeveral combinations of its acid with other baſes. He employed *ſal ammoniac*, *corneous metals*, and *marine ſalt* with earthy baſes. He alſo varied the matters which were to furniſh the inflammable principle; inſtead of urine he employed ſeveral vegetable coals, and even other animal matters, ſuch as the oil of hartſhorn, human blood, &c. But all theſe experiments were unſucceſsful, or yielded but a very ſmall quantity of phoſphorus. He found the neceſſity of returning to the uſe of the extract of urine: and Mr. Margraaf having tried to diſtil it alone, and being aſſured by comparative experiments that this extract produced as much phoſphorus when he diſtilled it alone as when he mixed it with matters capable of furniſhing marine acid, as, for inſtance, luna cornea, this able chemiſt then ſuſpected that the phoſphoric acid was different from that of common ſalt.

On the other ſide, as urine contains, beſides common ſalt, a conſiderable quantity of a ſingular kind of ſalt, which chemiſts call *fuſible ſalt*, or *native ſalt of urine* (*See* Urine), Mr. Margraaf, who found that he could not obtain phoſphorus from common ſalt, nor from any of the combinations of its acid with other baſes, was naturally led to ſuſpect that this native ſalt of urine contained the true phoſphoric acid. This he afterwards aſcertained by many demonſtrative experiments. Having diſtilled this ſalt only with inflammable matters, he eaſily obtained a very large quantity of phoſphorus; and alſo having diſtilled an extract of urine, from which he had ſeparated all the fuſible ſalt, and having by this method obtained ſcarcely any phoſphorus; and, laſtly, having examined and compared the properties of the phoſphoric acid with thoſe of the acid of the fuſible ſalt, and having found them entirely the ſame, he acquired on this ſubject all the certainty which is poſſible. We ſhall ſee from the enumeration of the properties of phoſphoric acid, how much it differs from the marine, and all other acids. To Mr. Margraaf alſo we owe the knowledge we have concerning this important ſubject.

When the inflammable principle of phoſphorus burns, and ſeparates from the acid by this combuſtion, the acid remains diſengaged, as the acid of ſulphur does, by the combuſtion of ſulphur. We obtain then, after the combuſtion of phoſphorus a ſubſtance at firſt dry, but which quickly and powerfully attracts the moiſture of air, becauſe the acid is ſo concentrated as to be dry. This matter is ſoon reduced to a very acid liquor, of the conſiſtence of very concentrated vitriolic acid. It has an acid taſte, it converts the blue color of vegetables to a red, and combines to the point of ſaturation with alkaline ſubſtances. Thus its acid quality is not doubtful. The fixity of this ſalt is very ſingular. It not only may be deprived by heat of all the moiſture by which it is kept liquid, but alſo when thus dried it may be rendered red-hot without ſublimation, and may be thereby changed into a ſolid and tranſparent matter, which has all the appearance of glaſs. Mr. Margraaf obſerved that phoſphoric acid, thus dried and heated, emitted a ſmell of garlic, and alſo ſome luminous ſparks; which proves that phoſphorus does not loſe by combuſtion all its phlogiſton, but that a portion of it ſtill remains united with the acid, and which ſeems to have been protected from combuſtion by this acid.

Phoſphoric acid appears to be a very powerful ſolvent. It eaſily decompoſes nitre and common ſalt, from which it diſengages the acids and unites with the alkaline baſes, as vitriolic acid does. According to Mr. Margraaf's experiment, it alſo decompoſed vitriolated tartar. Theſe remarkable properties ought probably to be attributed to its great fixity.

When it is combined to the point of ſaturation with alkaline ſalts, it forms neutral ſalts entirely ſimilar to the fuſible ſalt of urine.

Mr. Margraaf has alſo examined the action of the phoſphoric acid upon metals. From theſe experiments we find that this acid does not diſſolve gold, not even when mixed with the nitrous acid; which proves that it is very different from marine acid. It does not attack ſilver. It acted a little upon filings of copper, which rendered it green, but it eaſily diſſolved the calx of copper. Iron is entirely and eaſily ſoluble in this acid, and forms with it a cryſtallizable metallic ſalt. Tin is only weakly corroded by this acid, which muſt be well concentrated to produce even this corroſion. It has nearly the ſame effect upon lead. The color only of mercury, precipitated *per ſe*, is changed from a red to a yellow and a white, and by a long digeſtion to a black. It entirely diſſolves white arſenic. Laſtly, it diſſolves perfectly zinc, from the ſolution of which a fetid ſmell ariſes. This acid when treated by fuſion with metallic ſubſtances exhibits nearly the ſame phenomena, only with greater force; and with thoſe metallic matters which contain much diſengaged phlogiſton, as tin, lead, and eſpecially iron and zinc, it forms phoſphorus. Mr. Margraaf obtained a large quantity of excellent phoſphorus by diſtilling, with ſtrong heat, zinc and phoſphoric acid.

We ſhall now ſhew what effects are produced by this acid, when added to ſolutions of metals by other acids. At firſt it produces no change upon the ſolution of gold in aqua regia; but ſome time afterwards it precipitates part of the gold in its metallic ſtate. It affects the ſolution of ſilver nearly in the ſame manner, only that the quantity of ſilver thus precipitated, which reſembles ſilver precipitated by copper, is ſo ſmall, that it cannot be eſtimated. Mr. Margraaf adds, that by diſtilling to dryneſs this mixture of ſolution of ſilver with phoſphoric acid, a matter remained which did not differ from a *tranſparent luna cornea.* Nevertheleſs it was found to be not a true luna cornea, but a mixture only of ſilver with phoſphoric acid: for this matter, when placed upon a coal and heated with a blow-pipe, melted into a dark-grey glaſs. From the ſolution of mercury in nitrous acid, a copious white precipitate is formed by means of phoſphoric acid. But a ſingular circumſtance is, that this precipitate is rediſſolved, when the mixture has remained ſome time expoſed to the cold. Mr. Margraaf adds, that having diſtilled this mixture, he obtained a conſiderable quantity of a white and ſhining maſs, which by the heat of a blow-pipe was vitrified into a very tranſparent glaſs. But this circumſtance ſeemed very extraordinary, that after he had mixed the reſiduum with pure lead, and cupelled this mixture, he obtained a regulus of fine ſilver, the quantity of which was at the rate of ſix drams per quintal. A white precipitate was made from a ſolution of lead in nitrous acid by the phoſphoric acid; but this precipitate was not rediſſolved.

Theſe are the properties of phoſphorus, and of the phoſphoric acid; moſt of which were diſcovered and aſcertained by Mr. Margraaf. They ſhew that this acid differs no leſs from the marine than from other acids, and that its nature is peculiar. Mr. Margraaf, probably from the reſpect he has to the opinion of Stahl, does not abſolutely decide that it is different from the marine acid, but he ſays that it certainly is not pure and crude marine acid. He thinks, that poſſibly it may be marine acid very intimately combined with ſome ſubtle vitreſcible earth. And indeed the fixity and vitreſcibility which principally diſtinguiſh the phoſphoric acid, ſeem to ſhew that it contains a larger quantity of ſuch a principle than all other acids.

The phoſphoric acid ſeems at the ſame time to partake of the nature of *ſedative ſalt* and of *white arſenic*. Sedative ſalt, without having very diſtinct acid properties, acts as in acid on many occaſions. It combines with alkalis, ſaturates them, and reduces them to neutral ſalts. It is fixed in the fire, in which it melts as a vitreſcent matter, like the phoſphoric acid; like which alſo it decompoſes neutral ſalts. *See* BORAX *and* SALT (SEDATIVE).

Arſenic is not indeed fixed, as the phoſphoric acid is; and it decompoſes no other neutral ſalt than nitre: but it is diſpoſed to vitrification, and has a ſmell entirely ſimilar to that of the phoſphoric acid.

Phoſphoric acid is not found ſolely in animal urine. Mr. Margraaf found that many vegetable matters, particularly farinaceous grains, contain enough of this acid to produce phoſphorus, when they are expoſed to great heat in cloſe veſſels. This acid therefore is probably formed in the vegetable and animal kingdoms, and paſſes from the former into the latter: but the largeſt quantity of it is found in urine. *See* URINE *and* SALT (FUSIBLE) *of* URINE.

Hitherto phoſphorus has not been employed for any uſeful purpoſe. But we may hope that ſome uſe might be found for it, particularly if it could be made in large quantities and cheap, for its dearneſs has certainly prevented the proper trials and reſearches for this purpoſe. Although it were only to remain an object of curioſity, it would ſtill be amongſt the firſt of that kind. Many amuſing experiments may be made with phoſphorus, which would be more ſurprizing if it were leſs known. For inſtance, one may write upon a wall with a roll of phoſphorus, and the writing will preſently appear in letters of fire. The face, or any other object, may be covered over with phoſphorus diſſolved in oil, by which it is rendered luminous in a dark place, particularly if the air be heated a little. A taper may be extinguiſhed, and inſtantly kindled by applying to the wick while yet hot the point of a knife, to which a piece of phoſphorus has been fixed by means of ſuet. Finally, it is one of thoſe ſubſtances, by which ſuch magicians as *Comus* may perform operations which greatly ſurprize thoſe who are not in the ſecret.

DXXXVIII. PHOSPHORIC STONES. Theſe ſtones, when properly calcined, have the property of ſhining in the dark. The moſt celebrated and moſt anciently known phoſphorus of this kind, is that called the *Bolognian ſtone*, from Bolognia, a city of Italy, near which this ſtone is found. Lemery relates, that the perſon who firſt diſcovered the phoſphoric property of this ſtone was a ſhoe-maker, called Vincenzo Caſciarolo, who uſed to make chemical experiments. He ſays that this man, walking at the foot of Mount Paterno, gathered ſome of theſe ſtones, the great weight and luſtre of which had induced him to believe that they contained ſilver; and that after having expoſed them to fire, and carried them into a dark place, by accident probably, he perceived the ſtones ſhining like hot coals, which much ſurprized him, and induced him to repeat the experiment. From that time the Bolognian ſtone has been operated upon by chemiſts and experimental philoſophers, who have ſearched for the moſt advantageous method of calcining it to render it luminous.

For this purpoſe we find different proceſſes in the works of La Poterie, of Montalban, of Mentzel, of Lemery, and in the Memoirs of Homberg and du Fay, printed amongſt thoſe of the Academy. But nobody has treated this matter ſo fully, or illuſtrated it ſo well, as the celebrated Mr. Margraaf in two Diſſertations upon this ſubject. Wherefore, without attending to what has been ſaid before him, we ſhall relate here ſummarily his opinion concerning the nature of Bolognian ſtones, his method of preparing them, the phenomena they exhibit, and the matters analogous to them; ſo that the whole of this article ſhall be extracted from the Diſſertations of that able chemiſt.

Bolognian ſtone is ſoft, friable, heavy, cryſtallized, and incapable of effervescing with acids before it has been calcined in contact with fuel. Theſe qualities have induced Mr. Margraaf to claſs it amongſt the heavy fuſible ſpars, and with ſo much more juſtneſs, as all theſe ſpars by a preparation ſimilar to that for the Bolognian ſtone are rendered phoſphoric. As theſe ſpars are alſo compoſed of the ſame principles, as we ſhall afterwards ſee, all that we ſhall ſay concerning the Bolognian ſtone is alſo applicable to all other ſtones of the ſame kind; that is, to all the heavy fuſible ſpars, or rather to the *ſelenitic* ſpars.

When theſe ſtones are to be rendered phoſphoric, ſuch of them ought to be choſen as are the cleaneſt, beſt cryſtallized, moſt friable, moſt heavy, which exfoliate when broken, and, laſtly, which contain no heterogeneous parts. They are to be made red-hot in a crucible, and reduced to a very fine powder in a glaſs mortar, or upon a porphyry. Lemery affirms, that this pulverization ought to be made in a braſs mortar, and poſitively declares, that after many experiments, he found that the operation entirely failed, if any other, particularly an iron mortar, has been uſed. But Mr. Margraaf, whom we preferably follow, forbids expreſsly the uſe of a copper mortar, and affirms that it hurts the ſucceſs of the operation. The ſtones having been thus reduced to powder, are to be formed into a paſte with gum tragacanth, and divided into cakes as thin as a knife. Theſe are to be dried by a heat, which at laſt is to be made pretty conſiderable. After theſe preparations, an ordinary reverberatory furnace is to be filled to three quarters of its height with charcoal, and the fire is to be kindled. Upon this charcoal the flat ſurfaces of the cakes are to reſt; and more charcoal is to be placed above them, ſo as to fill the furnace. The furnace is then to be covered with its dome, the tube of which is to remain open; all the coal is to be conſumed, and the furnace is to be left to cool. The cakes are then calcined, and are to be cleanſed from the aſhes by blowing with bellows upon them. When they have been expoſed during ſome minutes to light, and afterwards carried into a dark place, they will ſeem to [illegible]

[illegible] expanded. Mr. Margraaf obſerves, that after this calcination through the coals, if the ſtones be expoſed to a ſtronger calcination during a full half-hour under a muffle, their phoſphoric quality will be rendered ſtronger.

The phenomena exhibited by theſe ſtones rendered phoſphoric by calcination are very worthy of attention, but are not well underſtood. The difficulty attending this ſubject, is encreaſed by the contradictory relations of thoſe who have operated upon this matter, in ſome important facts. Mr. du Fay, who has publiſhed a Memoir concerning this kind of phoſphorus in the year 1730, aſſerts, from experiments, that all calcareous ſtones, whether they contain, or not, vitriolic acid, are capable of becoming luminous by calcination; with this difference only, that the pure calcareous ſtones require a ſtronger or more frequently repeated calcination, whereas thoſe which contain an acid, as ſelenites, gypſums, ſpars, become phoſphoric by a ſlighter calcination. Mr. Margraaf, on the contrary, who does not ſeem to have known this Memoir of Mr. du Fay, ſays, that no other ſtones can be rendered phoſphoric but thoſe calcareous ſtones only which are ſaturated with an acid; that purely calcareous ſtones, as marble, chalk, limeſtone, ſtalactites, are incapable of receiving this phoſphoric quality, till they have been previouſly to their calcination ſaturated with an acid. The cauſe of this phoſphoric property cannot be aſſigned till theſe facts are aſcertained: for if all calcareous ſtones are capable of being rendered luminous without the concurrence of an acid, we may then ſuſpect that light is capable of adhering more to ſome bodies than to others, and that calcination gives to calcareous ſtones the property of retaining a larger quantity of light, and during a longer time, than other bodies can. We muſt nevertheleſs confeſs that this conjecture is very vague, and not much ſupported by facts.

But if theſe ſtones cannot be rendered luminous without the concurrence of an acid, as Mr. Margraaf thinks, and as experiments indicate; if even the acid does only contribute conſiderably to give them this property, as all experiments upon this matter, and even thoſe of Mr. du Fay, ſeem to ſhew; we then have reaſon to believe, that acids have a conſiderable ſhare in the production of this luminous property. Our conjectures upon this ſubject are as follow.

We know that acids in general, and particularly the vitriolic and nitrous, have a ſtrong affinity with the inflammable principle; that when they are united with this principle, they form with it compounds poſſeſſed of the properties of ſulphur or of phoſphorus. We are alſo certain, that ſulphur, phoſphorus, and probably other compounds of acid and phlogiſton with which we are not acquainted, have each two methods of burning;

ing; the firſt vivid and ſtrong, in which their phlogiſton forms a very ſenſible flame, and produces not only light, but alſo ſo conſiderable a heat as to kindle combuſtible bodies; the other ſlow and weak, capable only of producing a light much leſs vivid, without any ſenſible heat, or with a heat too ſmall to kindle combuſtible bodies. Such, for inſtance, is *gun-powder*. *See* SULPHUR, PHOSPHORUS, *and* POWDER (GUN).

This being eſtabliſhed, may we not with probability believe, that the acid contained in ſtones rendered phoſphoric by calcination combines with the phlogiſton of the coals, forming with it a ſulphureous compound; and that the phlogiſton of this kind of ſulphur or phoſphorus adhering but weakly to the acid, or exiſting there perhaps only ſuperabundantly, is very eaſily combuſtible; ſo that merely the action of the heat and light of the open air is ſufficient to inflame it: not, however, ſo ſtrongly as to produce heat and a total diſſipation of the phlogiſton, as when ſulphur and phoſphorus are burnt, but ſo ſlowly and weakly, that but a very faint light, obſervable only in the dark, is produced. Such is the light of the Bolognian and of other phoſphoric ſtones of the ſame kind.

Several phenomena of this phoſphorus ſeem capable of confirming this conjecture. Firſt, the Bolognian ſtone, the ſpars and gypſums which are rendered luminous by calcination, have, according to all thoſe who have operated upon them, a ſmell of ſulphur after their calcination, and preſerve this ſmell while they have the phoſphoric quality.

Secondly, the calcination of theſe ſtones muſt be made in contact with coals, otherwiſe they are not rendered luminous, as Mr. Margraaf has obſerved. But we are certain that this is one of the conditions neceſſary for the production of all ſulphurs, and of phoſphorus of all kinds: and as this calcination is alſo made with the concurrence of the air, and ſucceeds better in this manner than in cloſe veſſels, the ſulphureous compound formed in this operation is probably in a ſtate of inflammation and combuſtion during the calcination, which gradually diminiſh as the ſtone cools, ſo as to be rendered inſenſible by means of the great quantity of incombuſtible ſtoney matter with which the ſulphureous compound is covered and ſurrounded on all ſides: the combuſtion, however, does not ſo entirely ceaſe, but that merely the action of light is capable of renewing and encreaſing it, ſo as to render it ſenſible in the dark.

Thirdly, Mr. Margraaf has obſerved, that every phoſphorus of that kind which requires to be expoſed to light in order to make it ſhine in the dark, may, without any ſuch expoſure, during two or three days or [illegible] be rendered very luminous merely by being heated; that is, by [illegible] ſubſtance, which is at the ſame time incapable of giving light; [illegible] ſtance, a plate of iron heated, ſo [illegible] leaſt redneſs even in the dark. This curious experiment ſhews very clearly, that the phoſphoric light proceeds from a very weak and ſlow inflammation, which is ſo checked by cold, that no ſenſible light proceeds from it, even in the dark, but which may be encreaſed and renewed by a very weak heat. This matter might be further illuſtrated by obſerving the effects of expoſing this phoſphorus to a great degree of cold at the time of its being very luminous. We ſhould probably find that its light would be gradually diminiſhed, and at length extinguiſhed by the cold.

Thus we have ſtrong reaſons to believe, that the light of all theſe phoſphoric ſtones is nothing but a very ſlow and weak combuſtion or inflammation of a certain quantity of phlogiſton which they contain.

Many facts may indeed be objected to this opinion. 1. If the light of this phoſphorus was only the effect of a true inflammation, it could not take place without the free acceſs of air, and it would be extinguiſhed, like that of other inflamed ſubſtances, when phoſphorus is immerſed in water or any other liquid. But we are certain that theſe phoſphoric ſtones have the ſame effects when they are kept in bottles hermetically cloſed, or even when immerſed under water, as Mr. de Fay has ſhewn. 2. Mr. de Fay found by experiments, that ſtones purely calcareous, and containing no acid, are nevertheleſs rendered phoſphoric by calcination. But no ſulphureous or phoſphoric compound can be formed in theſe ſtones. Their light therefore does not ſeem to depend on any inflammation.

To theſe objections we may anſwer, that although in general inflammable bodies cannot burn with acceſs of air, this rule is not however free from exceptions, in the inſtances of ſulphureous and phoſphoric compounds, particularly concerning that kind of inflammation which is weak and incapable of kindling other combuſtible matters, which muſt be carefully diſtinguiſhed from their rapid combuſtion, as we have already remarked. We are certain that this weak and ſlow inflammation of ſuch bodies may ſubſiſt without acceſs of air, or at leaſt with much leſs air than is neceſſary for the other inflammation, and proportionable to its weakneſs. We cannot doubt that the light proceeding from the phoſphorus of urine is an effect of a weak combuſtion of this phoſphorus, as may be ſeen under the article Phosphorus *of* Kunckel. But this light is well known to appear in water, in oil, in the beſt cloſed glaſs veſſels, to encreaſe by heat and to diminiſh by cold, which alſo happens to the phoſphoric ſtones. Beſides, although theſe ſtones may ſhine as well as phoſphorus in water and in veſſels perfectly cloſe, their light is ſtill weaker than in open air, and is much more quickly extinguiſhed in water or other liquors than in air, according to the experiments of Mr. du Fay. In this reſpect then they are entirely ſimilar to the phoſphorus of urine: perhaps even ordinary ſulphur heated, and properly treated, might exhibit the ſame phenomena (*b*).

(*b*) I doubt whether a phoſphorus could be made of ſulphur without addition of quicklime or other ſubſtance, to which the vitriolic acid has a diſpoſition to unite. For the principal cauſe of that ſlow combuſtion which produces phoſphoric light ſeems to be, that the union between the acid and the phlogiſton of ſuch phoſphoric ſubſtances, is weakened by the preſence of ſome earth to which the acid has alſo a diſpoſition to unite; and that the phlogiſton is thereby gradually diſengaged, eſpecially when it is in contact with air, to which it is at all times ſtrongly diſpoſed to unite, as we may perceive from the neceſſary concurrence of that fluid to maintain ordinary combuſtion, which is only a more rapid and copious diſengagement of phlogiſton from the burning ſubſtances. Accordingly, if we examine the ſeveral kinds of phoſphorus, we ſhall find that each of them conſiſts of an acid, an earth, and phlogiſton. From Mr. Margraaf's experiments we find that the Bolognian and other phoſphoric ſtones contain a ſelenites, or a calcareous earth united with vitriolic acid, and that the phlogiſton is given to them during calcination. The phoſphorus of urine contains alſo an acid and phlogiſton. But from the experiments of the ſame excellent chemiſt we find, that this acid is always united with a peculiar earth. The phoſphorus of Homberg is a combination of marine

In the ſecond place, (as to Mr. du Fay's aſſertion, that calcareous ſtones become phoſphoric by calcination, we may obſerve, that as he did not examine chemically the ſtones he employed, and made no experiments to determine whether they contained any vitriolic acid or not, we cannot be certain that they did not contain any. For we know, that many of the ſtones which ſeem to be entirely calcareous, do however contain more or leſs of gypſeous or ſelenitic ſubſtances. Of this kind, perhaps, the ſtones employed by Mr. du Fay might be. Beſides, if we ſuppoſe that theſe ſtones contained no acid nor ſulphur, perhaps they are capable of retaining ſome of the phlogiſton of the coals in the calcination, and we may eaſily conceive that this phlogiſton alone is capable of producing a phoſphoric quality. Laſtly, we are certain, even from Mr. du Fay's experiments, that pure calcareous ſtones become much leſs luminous by calcination than thoſe which contain an acid, and are rendered phoſphoric much more difficultly.

After all that we have ſaid concerning phoſphoric ſtones, we ought to underſtand them clearly. The *phoſphorus of Baldwin* and the *phoſphorus of Homberg* are exactly ſimilar to thoſe made with the Bolognian ſtone and phoſphoric ſpars, from which they differ only in the kind of acid which they contain.

The *phoſphorus of Baldwin* is a combination of chalk with nitrous acid; and the *phoſphorus of Homberg* is a combination of quicklime with the acid of ſal ammoniac. The former is therefore a nitre with calcareous baſis, and the other a marine ſalt with calcareous baſis. They acquire the phoſphoric property by calcination, as well as the Bolognian ſtone and ſpars do, which are vitriolic ſalts with baſis of calcareous earth. Theſe two matters are not to be calcined in contact with fuel, but in crucibles. The phoſphorus of Baldwin receives its phlogiſton from the nitrous acid; chalk alſo contains ſome phlogiſton. The phoſphorus of Homberg receives its phlogiſton from the ſal ammoniac, which is treated with quicklime.

As the nitrous and marine ſalts with earthy baſes are deliqueſcent, they attract the moiſture of the air after they have been dryed, and even after they have loſt ſome of their acid by calcination; for which reaſon they cannot be preſerved but in veſſels accurately cloſed, and their phoſphoric quality laſts much ſhorter time than that of ſpars. The theory of theſe two kinds of phoſphorus ſeems to be exactly the ſame as that of phoſphoric ſtones. *See* SPAR.

DXXXIX. PINCHBECK. *See* BRASS *and* SIMILOR.

DXL. PITCH. (i)

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rine acid with calcareous earth, which abſorbs phlogiſton from the burning fuel during its fuſion. The phoſphorus of Baldwin is a ſimilar combination of nitrous acid with calcareous earth; and the pyrophorus of Homberg is a combination of vitriolic acid, earth of allum, and the phlogiſton of flour, or other inflammable ſubſtance.

(i) PITCH. When the wood of pines, firs, and other trees, from which turpentine is obtained, is expoſed to fire in veſſels which have openings only at their bottoms, as, for inſtance, in an inverted retort, the reſinous and other juices melt out by the heat, and at the ſame time acquire an empyreumatic ſmell and taſte. This is *tar*, which being boiled, exhales much acid phlegm and eſſential oil, and becomes thick. It is then changed into *pitch*. Pitch and tar conſiſt chiefly of the reſinous, but contain alſo much of the gummy, ſaline, and earthy matter of the wood. Hence they are not much diſpoſed to unite with oils and fats, and hence too they are gradually corroded by air and moiſture, when employed to preſerve wood, and other ſubſtances; as ſhips, caſks, ſhingles, DXLI. PITCH (MINERAL). (k)

DLXII. PLANTS. *See* Kingdom (Vegetable).

DXLIII. PLASTER. *See* Gypsum.

DXLIV. PLATINA. Platina is a perfect metal, analogous with the perfect metals, eſpecially with gold, as many properties are common to both.

Although metals, from their great utility, have been always diligently ſearched for, yet this has remained undiſcovered till lately, which is a very ſurpriſing circumſtance, and which ſeems to prove that platina is not, like the other metals, ſcattered in different parts of the world, and in all climates. Platina is found in the golden mines of Spaniſh America, and chiefly in thoſe of Santa Fé near Carthegena, and in the Bailliwick of Choco in Peru.

This metal was probably known to the workers of theſe mines long before it was brought into Europe: but as its color is not very fine, and as it is almoſt intractable, eſpecially by fuſion, without addition, they ſeem to have neglected it, conſidering it as ſome refractory mineral or marcaſite: ſome of them, however, had attempted to melt it, and to make toys of it, as tobacco-boxes and other things of that kind; but this muſt certainly have been by allaying it with other metals, as we ſhall ſoon ſee the impoſſibility of their doing it otherwiſe.

Nevertheleſs, this metal continued to be ſo neglected, that it was entirely unknown in Europe till Don Antonio Ulloa, a Spaniſh mathematician, who accompanied the French academicians ſent by the King of France to Peru to determine the figure of the earth by meaſuring a degree of the meridian, firſt mentioned it in the relation of his voyage, printed at Madrid in the year 1748: but he ſays little of it, and repreſents it as an intractable metallic ſtone, which impeded the extraction of gold from the ore when it was in a large quantity. This account was not very likely to excite the curioſity of chemiſts concerning a new perfect metal, and a matter ſo intereſting and ſurpriſing as they afterwards found it to be.

But before that time, that is, in 1741, an Engliſh metallurgiſt, called *Wood*, who had brought from Jamaica ſome ſpecimens of it, which he was informed had come from Carthagena, attended more to it, and made ſome good chemical trials

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ſhingles, &c. To render them more durable, and leſs liable to be melted by the heat of the ſun in ſummer, an anonymous author adviſes that tar ſhould be mixed when boiling-hot with coal-duſt, in ſuch quantity as to render it thick; by which preparation, he ſays, tar is fixed, never runs, bends and hardens ſurprizingly from heat and moiſture.

From two ounces of pitch, one ounce and half a ſcruple of reſinous matter were extracted by ſpirit of wine. Half an ounce of empyreumatic oil ſeparated during the digeſtion, and nearly half an ounce of earthy matter remained, from which water extracted nothing. The ſame quantity of the ſame pitch, boiled firſt in water, yielded two drams and half a ſcruple of gummy extract.

Eight ounces of pitch diſtilled in an open fire yielded two ounces one dram and a half of an acid ſpirit, and two ounces five drams of a fetid oil, three ounces of a ſhining black coal remaining in the retort. *Neuman.*

(k) Pitch (Mineral). This is a fetid, black, thick, and tenacious bitumen, differing from petroleum in having a thicker conſiſtence and a darker color. Petroleum, expoſed to evaporation, depoſites a ſubſtance ſimilar to mineral pitch. It is uſed for the ſame purpoſes for which pitch and tar are applicable.

of it. Since that time, ſeveral chemiſts, the chief of which are M. Scheffer, of the Swediſh Academy, and Dr. Lewis, of the Royal Society of London, have very particularly examined this ſingular metal, and have publiſhed their experiments. Dr. Lewis has in ſome meaſure exhauſted this matter, in four excellent memoirs communicated to the Royal Society. Platina was, nevertheleſs, little known in France till the year 1758, when Mr. Morin, zealous for the progreſs of ſcience, collected, tranſlated into French, and publiſhed an account of all that had hitherto been done upon platina, in a work entitled, *Platina, White Gold, an eighth Metal.*

This publication excited the curioſity of French chemiſts, to whom it was a new and intereſting object; but the difficulty of obtaining a matter ſo dear prevented all of them from being able to ſatisfy their deſire of examining it. Meſſrs. Macquer and Beaumé were the only perſons who made experiments upon it, which they have publiſhed amongſt the Memoirs of the Academy for the year 1751.

About the ſame time alſo, Mr. Margraaf examined platina, and publiſhed a diſſertation concerning it.

Theſe are the only chemiſts who have examined, at leaſt, who have publiſhed their reſearches concerning this new metal. But although their number be ſmall, yet their experiments are ſo numerous, made with ſuch accuracy, and in general ſo conſiſtent with each other, that by collecting and comparing them, we may acquire as certain and almoſt as extenſive knowledge of platina as of the other metals that have been known from time immemorial. This article ſhall contain the moſt general and certain reſults of the experiments made by the above-mentioned chemiſts.

Platina, a Spaniſh word, is a diminutive of *plata*, which in that language ſignifies ſilver. It is therefore called by the Spaniards *little ſilver*. This name is improper, ſince it reſembles ſilver only in being indeſtructible, and very imperfectly in its color. The name of *white gold*, given to it by ſome chemiſts, is more ſuitable; for we ſhall ſee that it reſembles gold more than any one metal reſembles any other; and hence we ſhall chiefly compare it to gold.

We do not certainly know the origin and natural hiſtory of platina. We can only aſſert, that all that we ſee in maſſes, or worked into forms, is not pure nor in its natural ſtate; for we are certain that it is unfuſible, without addition, by the moſt violent fire of our furnaces. All the platina that is found in the cabinets of curious perſons conſiſts of ſmall angular grains, the corners of which are a little rounded. It is mixed with a conſiderable quantity of ſmall black ſand, as attractable by magnets as the beſt iron, but unſoluble by acids, unfuſible, and untractable. This ſand is perfectly ſimilar to that which is found at St. Quay in Bretagne. The grains of platina are alſo frequently interſperſed with particles of ſpar and of quartz, and ſometimes with ſpangles of gold. Meſſrs. Macquer and Beaumé found a pretty large ſpangle of gold in the platina examined by them. But theſe heterogeneous matters are quite foreign to platina, and are not combined with it; for it contains nothing extraneous excepting a little gold and mercury, which latter ſubſtance it probably receives during the operations for extracting gold from the ores by means of mercury. Theſe matters may eaſily be ſeparated from the platina without decompoſing it, by waſhing and by magnets. Some chemiſts, who know platina only by name, and deny that it is a peculiar metal, have therefore, with great impropriety, advanced, that Mr. Margraaf had decompoſed it, and had obtained from it gold, iron, and arſenic. The contrary appears from Mr. Margraaf's Diſſertation. Mr. Margraaf only ſeparated the heterogeneous matters which were merely mixed with platina, as other chemiſts have done; but he is too good a chemiſt to pretend that he has decompoſed it: on the contrary, he does not heſitate to call it a *perfect metal*, which name is alſo given to it by all who underſtand metals.

The color of the grains of platina is metallic, white, livid, not very brilliant, intermediate betwixt the white of ſilver and the grey of iron. At firſt view they reſemble large filings of iron. They are ſmooth, and are nearly as hard as iron; they are ſomewhat ductile; ſo that ſome of them may be flattened upon an anvil, while others are bruiſed into ſmall pieces.

The ſpecific gravity of platina is very great, and nearly equal to that of gold. In water it loſes only ſomething betwixt an eighteenth and a nineteenth part of its weight.

The tenacity of the parts of this metal has not been determined, becauſe it cannot be formed into a proper figure to make the experiment. But if this quality is proportionable to the ductility and hardneſs of metals, we may preſume, that as platina is much harder than gold, its tenacity is alſo greater, if all the ductility of which it ſeems ſuſceptible could be given to it by art.

Platina is, like pure gold and ſilver, free from all ſmell and taſte. It is unalterable by the combined action of air and water, and is no more ſuſceptible than the other perfect metals of acquiring ruſt. Like them alſo, it is indeſtructible by the moſt violent and long continued fire: but the property which peculiarly diſtinguiſhes this metal is its infuſibility by the moſt intenſe heat.

As fuſion is neceſſary for the application of metals to uſe, chemiſts have made their utmoſt efforts to melt platina. The moſt violent heat which could be raiſed in air furnaces, or by the united action of ſeveral large bellows, has been applied repeatedly, and continued a long time without ſucceſs. In all theſe trials the grains of platina remained unaltered in form and weight, and were only agglutinated to each other, nearly as ſand is by expoſure to violent heat, but ſo ſlightly, that by the ſmalleſt effort they were ſeparable. Meſſrs. Macquer and Beaumé expoſed platina during five days and five nights to the greateſt heat of a glaſs-houſe furnace, which trial did only confirm the unfuſibility and unalterability of platina by ordinary fires, as it was found to be only a little agglutinated, and its weight to be a little encreaſed; which latter phenomenon has been alſo obſerved by Mr. Margraaf. Laſtly, Meſſrs. Macquer and Beaumé, having expoſed platina to the focus of a large burning-glaſs, melted a little of it in a minute. It firſt ſmoked, then emitted ſparks, and thoſe parts of it melted well which were expoſed to the center of the focus. Theſe chemiſts carefully examined the properties of this platina. According to their memoir, the melted parts were diſtinguiſhable from the others by a brilliancy like that of ſilver, and by a rounded, ſhining, poliſhed ſurface. They were eaſily flattened upon an anvil, and formed into very thin plates without cracking or ſplitting; ſo that theſe grains ſeemed to be much more malleable than platina in its natural ſtate. Theſe metals by repeated ſtrokes of the hammer became hard and brittle, as all other metals do, particularly gold and ſilver; and by annealing, their malleability was reſtored, as it is alſo to other metals by the ſame means. After experiments ſo certain and well authenticated, we cannot doubt that platina is truly a metal, and even a third metal, as perfect in its kind as gold and ſilver are in theirs. This propoſition will be further confirmed by the other properties of platina.

Platina reſiſts as perfectly as gold the action of the vitriolic, marine, or nitrous acids; in a word, of any pure acid, in whatever manner applied. Theſe acids, concentrated or diluted, may be boiled any length of time upon platina without diſſolving an atom of it: but a mixture of nitrous and marine acids, aqua regia, the ſolvent of gold, is alſo the ſolvent of platina. Meſſrs. Macquer and Beaumé have obſerved, that an aqua regia compoſed of equal parts of the two acids diſſolves moſt of this metal. But, however the aqua regia is made, more of it is required to diſſolve platina than gold. Theſe chemiſts employed a pound of aqua regia to diſſolve an ounce of platina. All the acid of this quantity of aqua regia was not indeed employed to diſſolve the platina, becauſe much of it was diſſipated in vapors during the operation, from the long time employed in the ſolution; and therefore if the operation had been performed in cloſe veſſels, and by diſtillation and cohobation, as Dr. Lewis did, a leſs quantity of aqua regia would have been ſufficient: but this is a matter of ſmall importance.

Aqua regia requires to be aſſiſted by the heat of a ſand-bath, and alſo a conſiderable time, to diſſolve platina well. Although the color of this metal is white, its ſolution is very yellow, even deeper than that of gold. When a ſmall quantity of platina only is diſſolved in aqua regia, or when a ſaturated ſolution is much diluted, a beautiful yellow color is produced, undiſtinguiſhable from that of a ſolution of gold: but while the aqua regia becomes more and more ſaturated with platina, its color becomes more and more intenſe, and at laſt red; but this apparent redneſs evidently proceeds from nothing but the intenſity of the yellow color; for this ſaturated ſolution is rendered yellow by dilution with water. In this circumſtance it is ſimilar to tincture of ſaffron.

The ſolution of platina in aqua regia is acid and corroſive, and from it a neutral cryſtallizable ſalt may be obtained. When the acids employed are concentrated, and when the ſolution is nearly ſaturated, a confuſed cryſtallization is formed at the bottom of the matraſs, which may be found to be a heap of very ſmall, yellow, tranſparent cryſtals. Theſe cryſtals of platina may be obtained much larger and more beautiful by evaporating the ſolution of platina with a very ſlow fire, and by cooling it very ſlowly. I found that the ſolution of platina tinged the ſkin and other animal matters with a blackiſh brown color, in certain circumſtances (in which reſpect it reſembles the ſolutions of gold, ſilver, and of mercury), and that ether mixed with this ſolution by agitation quickly ſeparates from it, and becomes tinged with a fine yellow color, preciſely as it does when it is treated in the ſame manner with a ſolution of gold. This experiment ſhews, that ether, and probably other attenuated oily matters, take platina, as they do gold, from aqua regia; and hence we may perceive another inſtance of the conformity of theſe two metals. But as ether does not acquire nearly ſo intenſe a color as the ſolution of platina, we may infer that it only receives a ſmall quantity of this metal. Beſides, the platina ſoon ſeparates ſpontaneouſly from the ether.

Platina may be precipitated from its ſolvent by fixed and volatile alkalis (*l*); and theſe precipitates are all of a yellow brick-color, when only ſo much alkali is employed as is neceſſary to ſaturate the acid of the ſolution; but are of a paler color when a ſuperabundant quantity of alkali is employed, or when they are digeſted in alkali. Theſe colors of precipitates of platina proceed from a large quantity of ſaline matters which precipitate along with them, and which ſtrongly adhere to them, and not from any calcination of this metal, or loſs of its phlogiſton. The proof of this is, that if the cryſtals or precipitates of platinà be expoſed to ſtrong heat, the ſaline matters which adhere to them are expelled, the color occaſioned by them is loſt, and the platina recovers without any addition its ordinary metallic ſtate.

All the above-mentioned phenomena exhibited by platina treated with acids and alkalis are ſimilar to thoſe which gold exhibits in ſimilar circumſtances: but platina has alſo in this reſpect ſome peculiar properties by which it differs from gold. 1. The ſolution of platina acquires a deeper color than that of gold. 2. The precipitate of platina made by volatile alkali does not fulminate as that of gold does. 3. Tin does not produce from the ſolution of platina a purple precipitate, capable of tinging glaſs, as it does from a ſolution of gold.

Neither nitre, which quickly and effectually calcines all imperfect metals; nor corroſive ſublimate, the acid of which, being very much concentrated, acts upon almoſt all metals; nor any other neutral ſalt, could occaſion the ſmalleſt alteration upon platina or upon gold.

This ſingular metal reſiſts, as well as gold does, the action of ſulphur, which ſo powerfully diſſolves other metals. From Dr. Lewis's experiments we find, that liver of ſulphur is capable of diſſolving platina, as it does alſo gold, by fuſion. Mr. Margraaf's experiments leave this matter uncertain: but if, as we have reaſon to believe, liver of ſulphur does diſſolve platina, this is another inſtance of the conformity of this metal with gold.

Almoſt all metallic ſubſtances are capable of ſeparating platina from aqua regia, as they alſo ſeparate gold. Platina precipitated by theſe ſubſtances has its metallic appearance. In this reſpect it conforms with a general rule, that metals precipitated by other metals have their metallic appearance. *See* PRECIPITATION.

Mr. Margraaf relates, in his Memoir, a great number of experiments which he made to diſcover the effects of mixing a ſolution of platina with other metallic ſolutions, and alſo of digeſting pure platina with theſe ſolutions and other ſaline ſubſtances. Theſe experiments furniſhed many curious and intereſting facts; but as ſeveral of them do not ſeem to be conſiſtent with the eſſential and aſcertained properties of platina, nor even with ſimilar experiments made by other chemiſts, we have reaſon to believe that theſe ſingularities obſerved by this able chemiſt proceeded from ſome extraneous matters with which his platina was

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(*l*) Mr. Margraaf mentions a very ſingular fact concerning the precipitation of platina by alkalis; namely, that although vegetable fixed alkali, and even volatile alkali, precipitated this metal from aqua regia; yet the mineral alkali, though in other inſtances equal in power of union to the former alkali, and ſuperior to the latter, produced no precipitation, even when ſo much of it was added as to ſaturate the acid, nor even diſturbed the tranſparency of the liquor.

allayed. From moſt of theſe experiments, as, for inſtance, from the yellow flowers obtained by ſubliming platina with ſal ammoniac, and from the blue precipitate formed by mixing his ſolution of platina with a lixivium of Pruſſian blue, we may conclude, that iron was the metal with which his platina was allayed, as he himſelf ſays.

Platina, like gold, is capable of being allayed with all metals, and in theſe allays exhibits intereſting phenomena. Dr. Lewis has examined theſe allays more carefully and fully than any other perſon. As we have ſaid nothing of it under the article Allay, we ſhall ſummarily mention here what Dr. Lewis has obſerved on this ſubject.

Platina, although very unfuſible when alone, may however be fuſed along with other metals with which it is capable of combining. Equal parts of gold and platina may be melted in a violent fire, and the allay which is formed may be eaſily poured into an ingot mould. It is whitiſh, hard, and may be broken by a violent blow. Nevertheleſs, when it has been well annealed, it is capable of conſiderable extenſion under the hammer. One part of platina and four parts of gold may be melted and allayed with a much leſs fire than is requiſite in the preceding experiment. This allay is ſo ductile, that it may be extended into very thin plates without being broken, or even ſplit at the edges. Dr. Lewis obſerved a remarkable circumſtance concerning this allay, namely, that the platina, which was $\frac{1}{5}$ of the whole maſs, rendered the gold no paler than guineas are, which contain only $\frac{1}{12}$ of ſilver.

Silver and platina may be melted and allayed together in equal parts with a very violent fire. The allay which is formed is much harder and darker-colored than ſilver, and of a large grain, although it preſerves ſome ductility. Theſe qualities are leſs ſenſible when one part of platina is added to ſeven parts of ſilver: but this allay is ſtill coarſer-grained and leſs white than ſilver. This coarſeneſs of grain ſhews an imperfect union; and indeed ſilver and platina do not ſeem to unite very intimately; for Dr. Lewis obſerves, that when the allay of theſe two metals was left after fuſion in the crucible, a conſiderable part of the platina was ſeparated and ſunk to the bottom. The platina did not appear to communicate any good quality to the ſilver, excepting a greater hardneſs.

Copper ſeems to be moſt improved by being allayed with platina. When indeed a large proportion of platina is added to copper, as equal parts or two-thirds, the allay is hard, brittle, and coarſe: but when a leſs quantity of platina is added, as from $\frac{1}{6}$ to $\frac{1}{23}$, or even leſs, a golden-colored copper is produced, very malleable, harder, ſuſceptible of a finer poliſh, ſmoother-grained, and much leſs ſubject to calcination and ruſt than pure copper.

Dr. Lewis was not able to fuſe forged iron with platina, which is not ſurprizing, when we conſider the refractory qualities of theſe two metals: but he allayed platina with caſt-iron, by throwing one part of platina to four parts or more of the iron when it was juſt beginning to flow. This allay was much harder, and much leſs ſubject to ruſt, than pure iron. It was ſuſceptible of a very fine poliſh.

Platina may be melted with tin in all proportions from equal parts of the two metals to twenty-four parts of tin. This allay was obſerved to be ſo much harder, more brittle, more dark-colored, and coarſer, as the proportion of the platina was larger. No advantage ſeemed to be acquirable by this allay. Lead alſo may be allayed in different proportions with platina, nearly as tin may, with this difference, that a much greater fire is neceſſary for the formation of this latter allay, particularly when the quantity of platina is great. The metal reſulting from it has a dark color, ſomewhat approaching to a purple or violet, or it eaſily acquires theſe colors when expoſed to the air. When the two metals fuſed together are left in a crucible to cool, a conſiderable part of the platina ſeparates and falls to the bottom, in the ſame manner as it does from the allay of ſilver.

From Dr. Lewis's experiments platina appears to be capable of amalgamating with mercury, but difficultly, and by a very long trituration with water, as, for inſtance, during a week.

If mercury be triturated with an allay of gold and platina, it ſeizes the gold, and does not touch the platina. Dr. Lewis propoſes this amalgamation as a method of ſeparating theſe two metals; and it is that which is employed in the ores of Peru, in which gold and platina are mixed together: but we do not yet know whether this ſeparation be perfectly complete.

Platina may be allayed with biſmuth nearly as with lead, and in a ſimilar manner ſeparates from the biſmuth after fuſion. It gives to biſmuth alſo, as it does to lead, the property of acquiring, by expoſure to air, violet, purple, or blue colors. This allay is always very brittle.

Of all metallic matters zinc may be moſt eaſily allayed with platina, and moſt effectually diſſolved by fuſion. Dr. Lewis obſerved, that theſe allays did not appear very different from pure zinc; but that when the proportion of platina is conſiderable, their grain is cloſer, their color leſs clear, and more bluiſh than of zinc. They do not tarniſh, nor change colors, by expoſure to air. Laſtly, they are harder than zinc, and have not the ſemi-malleability of this ſemi-metal.

With regulus of antimony platina formed a darker and harder compound than the pure regulus.

Dr. Lewis has combined platina at the ſame time with two metallic matters, ſuch as with braſs compoſed of copper and zinc, and with bronze compoſed of copper and tin. The moſt ſingular phenomenon of this latter allay was, that the copper and tin acting conjointly upon the platina was capable of diſſolving more of it than they both could do ſeparately. This allay was hard and capable of receiving a fine poliſh, but is ſubject to tarniſh, which ſeems to happen to all the allays of tin or of lead with platina.

Equal parts of platina and braſs formed a compound very hard and very brittle, capable of receiving a very fine poliſh, and not ſubject to tarniſh. It might therefore be employed for ſpeculums of teleſcopes, and would be much preferable to thoſe now uſed, all which have the great diſadvantage of tarniſhing by expoſure to air, and even very quickly.

Dr. Lewis does not mention the effects of allaying platina with arſenic; but Mr. Scheffer affirms, that if only a twentieth part of arſenic be added to platina when red-hot in a crucible, theſe two ſubſtances will be perfectly fuſed, and will form a brittle, grey maſs. This remarkable experiment requires confirmation: for Mr. Margraaf having alſo treated theſe two matters together, did not perceive any ſuch action of arſenic upon platina. From one of his experiments we find, that having expoſed to a violent fire during an hour a mixture of an ounce of platina with a fuſible glaſs compoſed of eight ounces of minium, two ounces of flints, and one ounce of white arſenic, he obtained a regulus of platina, well united and fuſed, which weighed an ounce and thirty-two grains, the ſurface of which was ſmooth, white and ſhining, and the internal parts grey, but which nevertheleſs appeared ſufficiently white when it was filed.

The cupellation of platina was one of the moſt important experiments to be made; becauſe if this operation ſucceeded perfectly, we might thereby obtain compact and malleable maſſes of pure platina, in the ſame ſtate as a metal which had been well fuſed, and of which all ſorts of utenſils might be made, if not by caſting it, at leaſt by forging. All the chemiſts who have examined this metal, and particularly Dr. Lewis, have uſed their utmoſt endeavours to cupel it well. But although they have uſed every expedient to apply the ſtrongeſt heat, they have not perfectly ſucceeded. The ſcorification proceeds well at the beginning of the operation, as when gold and ſilver are cupelled: but the cupellation afterwards becomes more and more difficult; becauſe, as the quantity of lead diminiſhes, the matter becomes leſs and leſs fuſible, and at laſt ceaſes to be fluid, notwithſtanding the moſt violent heat; and alſo becauſe, when the quantity of platina is greater than that of the lead, this latter metal is protected, and is not converted into litharge. Hence the regulus obtained is always dark-colored, rough, adhering to the cupel, brittle, and weighing more than the platina originally employed, from the lead which remains united with it. Meſſrs. Macquer and Beaumé appear nevertheleſs to have carried this experiment further than any other chemiſts, as they kept the matter expoſed to a violent fire during a longer time, that is, about fifty hours ſucceſſively; therefore, although their platina was tarniſhed and rough on its ſurface, it was internally white and ſhining, eaſily ſeparable from the cupel, and a little diminiſhed in weight, a certain proof that no lead remained in it. This platina was alſo ductile, and capable of extenſion under the hammer. Cupellation is therefore a certain method of applying platina to uſe, and of forming it into utenſils.

The ſciences, commerce, and arts muſt receive great advantages from the application of a new perfect metal to uſeful purpoſes, which to the fixity and indeſtructibility of gold unites a hardneſs and ſolidity almoſt equal to thoſe of iron; which is unalterable by the action of water and air; is not ſubject to ruſt; and reſiſts as well as glaſs or earthen veſſels all ſalts, even aqua fortis and other pure acids. We regret, that although large quantities of it are found in America, it is ſo exceedingly rare here.

The cauſe of this great ſcarcity of platina is, that the Spaniſh Miniſtry have prohibited the ſale of it, or the extraction of it from the mines. Theſe prohibitions were certainly from good motives and wiſe intentions; for this metal was no ſooner known than it was employed for the adulteration of gold, for which purpoſe it is very fit, as it ſuſtains all the ordinary trials of gold, has the ſame ſpecific gravity, and renders gold much leſs pale than ſilver. The uſe of a metal with which frauds ſo prejudicial might be committed with impunity was neceſſarily interdicted: but ſince the beſt chemiſts of Europe have examined platina, they have publiſhed certain and eaſy methods by which the ſmalleſt quantity of platina mixed with gold may be diſcovered, and by which theſe metals may be ſeparated, in whatever proportion they may happen to be united. Theſe methods may be ſeen in the Memoirs of the chemiſts who have examined this matter. We ſhall here relate only one of the moſt convenient and leaſt troubleſome. It is founded on a property which gold has, and not platina, of being capable of precipitation from aqua regia by martial vitriol; and upon a property which platina has, and not gold, of being capable of precipitation from aqua regia by ſal ammoniac. When therefore we would diſcover if gold be allayed with platina, let it be diſſolved in aqua regia, and to this ſolution, which will contain both metals, let ſome ſal ammoniac diſſolved in water be added, upon which the platina will be precipitated in form of a brick-colored ſediment. If, on the other ſide, we would know if platina contained any gold, let this platina be diſſolved in aqua regia, and to the ſolution add a ſolution of martial vitriol in water, upon which the liquor will become turbid, and the gold will form a precipitate which may be eaſily ſeparated by decanting and filtrating the liquor.

We may then affirm, that the reaſons which induced the Spaniſh Miniſtry to interdict the uſe of platina no longer ſubſiſt; and we hope that when they are once convinced of this, ſociety ſhall no longer be deprived of a ſubſtance which may be ſo advantageous to them, and which may be a new ſource of wealth to the Crown of Spain, the ſole proprietor of this precious treaſure.

DXLV. PLUMBUM CORNEUM. This is a combination of lead with marine acid. It is a metallic ſalt which may be made by combining directly lead with that acid: but this proceſs is not much uſed, becauſe others are more convenient. For inſtance, by pouring ſome marine acid, or the ſolution of a ſalt containing it, into a ſolution of lead made by the nitrous acid, we obtain a plumbum corneum, which falls down to the bottom of the veſſel, if the liquor does not contain too much water. A ſimilar combination may be made by diſtilling calxes of lead, as minium, for inſtance, with ſal ammoniac. The lead diſengages the volatile alkali of this ſalt, and unites with its acid, which is the ſame as that of common ſalt.

Lead united with marine acid has ſome reſemblance to luna cornea, which is a combination of ſilver with the ſame acid; and hence has been called plumbum corneum. Like the luna cornea, it is ſemi-volatile and cryſtallizable, but is infinitely more ſoluble in water. This combination is not uſed in the arts, and little in chemiſtry. *See* LEAD.

DXLVI. POMPHOLIX. This is one of the names given to the flowers of zinc ſublimed during the deflagration of this ſemi-metal. *See* FLOWERS *of* ZINC *and* ZINC.

DXLVII. PORCELAIN. Porcelain is the moſt beautiful and fineſt of all earthen wares. All earthen wares which are white and ſemi-tranſparent are generally called porcelains: but amongſt theſe ſo great differences may be obſerved, that notwithſtanding the ſimilarity of their external appearance, yet when they are examined chemically, they cannot be conſidered as matters of the ſame kind. Theſe differences are ſo evident, that even perſons who are not connoiſſeurs in this way prefer much the porcelain of ſome countries to that of others.

As the ſeveral kinds of porcelain differ ſo much from each other, no general proceſs can be given for making it. We ought therefore to confine ourſelves to deſcribe and conſider the manufacture of ſome particular porcelain, remarkable for its excellence and beauty. But this alſo is almoſt impracticable; becauſe in all the manufactories where it is made, both in France and other countries, the ingredients and method of preparation employed are carefully concealed. Nevertheleſs, we have a general knowledge of the principal operations of this manufacture, which we ſhall here deliver; and that we may ſupply the details which we cannot deſcribe, we ſhall give our opinion concerning the qualities which the beſt porcelain ought to have. This ſeems to be neceſſary, as the manufacture of porcelain is an object more attended to than ever; and as many perſons, otherwiſe intelligent, talk and judge of it without having any preciſe notions on the ſubject.

The art of making porcelain is one of thoſe in which Europe has been excelled by oriental nations. The firſt porcelain that was ſeen in Europe was brought from Japan and China. The whiteneſs, tranſparency, fineneſs, neatneſs, elegance, and even the magnificence of this pottery, which ſoon became the ornament of ſumptuous tables, did not fail to excite the admiration and induſtry of Europeans. I ſhall not here relate the hiſtories of the ſeveral attempts made in Europe to imitate the oriental porcelain, as moſt of them are unknown, and would lead us too far from the ſubject. I ſhall only ſay, that in different parts of Europe, earthen wares have been made ſo like the oriental that they have acquired the name of porcelain. Neither ſhall I inquire into the æra of the eſtabliſhment of the ſeveral manufactures of porcelain in Europe. I ſhall only ſay, that I believe the firſt European porcelains were made in Saxony and in France; and afterwards in England, Germany, and Italy. But as all theſe were different from the Japaneſe, ſo each of them had its peculiar character.

We now proceed to determine the quality of the principal porcelains, namely, thoſe of Japan or of China, of Saxony and of France.

The illuſtrious Reaumur firſt attended to this object, and communicated his reſearches in two Memoirs before the Academy of Sciences in 1727 and 1729. This great experimental philoſopher took the beſt method of arriving at a thorough knowledge of the ſubject; and although he was miſtaken in ſome points, and altho' he neglected to conſider ſome of the eſſential qualities requiſite to conſtitute good porcelain, he is nevertheleſs the firſt perſon who publiſhed any diſtinct notions upon the ſubject. He did not ſatisfy himſelf with conſidering the external appearance, the painting and gilding, which are only ornaments not eſſential to the porcelain, but he endeavored to examine it internally: And having broken pieces of the Japaneſe, Saxon, and French porcelains, he examined the difference of their *grains* (which name is given to their internal ſtructure). The grain of the Japaneſe porcelain appeared to him to be fine, cloſe, compact, moderately ſmooth, and ſomewhat ſhining. The grain of the Saxon porcelain was found to be ſtill more compact, not granulous, ſmooth, ſhining like enamel. Laſtly, the porcelain of St. Cloud had a grain much leſs cloſe and fine than that of Japan, not, or but little ſhining, and reſembling the grain of ſugar.

From theſe firſt obſervations Mr. Reaumur perceived that porcelains differed conſiderably. That he might examine them further, he expoſed them to a violent heat. More eſſential differences than thoſe of the grain appeared upon this trial; for the Japaneſe porcelain was unaltered by the fire, and all the European were melted, as Mr. Reaumur ſays.

This eſſential difference betwixt the Japaneſe and European porcelains ſuggeſted to Mr. Reaumur a very ingenious thought, and in many reſpects true, concerning the nature of porcelain in general. As all porcelains ſomewhat reſemble glaſs in conſiſtence and tranſparency, tho' they are leſs compact and much leſs tranſparent, Mr. Reaumur conſidered them as *ſemi-vitrifications*. But every ſubſtance may appear, and may actually be in a ſemi-vitrified ſtate in two manners: for, firſt, it may be entirely compoſed of vitrifiable or fuſible matters; and in this caſe, by expoſing it to the action of fire, it will be actually melted or vitrified, if the heat be ſufficiently ſtrong and long-continued. But as this change is not made inſtantly, eſpecially when the heat is not very violent, and as it paſſes through different ſtages or degrees, which may be more eaſily obſerved as the heat is better managed; hence, by ſtopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate ſtate betwixt thoſe of crude earths and of completely vitrified ſubſtances; and alſo poſſeſſed of the ſemi-tranſparency and of the other ſenſible qualities of porcelain. We know alſo, that if ſuch porcelain be expoſed to a ſtronger degree of fire, it will then be completely fuſed and entirely vitrified. But moſt of the European porcelains have this fuſibility, from which Mr. Reaumur concludes, that their compoſition is founded upon the above-mentioned principle.

In the ſecond place, a paſte of porcelain may be compoſed of fuſible and vitrifiable matter, mixed with a certain proportion of another matter which is abſolutely unfuſible in the fires of our furnaces. We may eaſily perceive, that if ſuch a mixture be expoſed to a heat ſufficient to melt entirely the vitrifiable ingredient, that this matter will actually melt; but as it is intermixed with another matter which does not melt, and which conſequently preſerves its conſiſtency and opacity, the whole muſt form a compound partly opake and partly tranſparent; or rather a ſemi-tranſparent maſs; that is, a ſemi-vitrified ſubſtance, or porcelain, but of a kind very different from the former; for as the fuſible part of this latter has produced all its effect, and as it has been as much fuſed as it can be during the baking of the porcelain, the compound may be expoſed a ſecond time to a more violent fire without approaching nearer to a compleat vitrification, or without departing from its ſtate of porcelain. But as oriental porcelain has preciſely theſe appearances and properties, Mr. Reaumur concludes with reaſon, that it is compoſed upon this principle; and he afterwards confirmed his opinion by undeniable facts.

Father *Entrecolles*, miſſionary at China, had ſent from thence a ſummary deſcription of the proceſs by which the inhabitants of that country make their porcelain; and alſo a ſmall quantity of the materials which they employ in its compoſition. He ſaid that the Chineſe compoſed their porcelain of two ingredients, one of which is a hard ſtone or rock, called by them *petuntſe*, which they carefully grind to a very fine powder; and the other, called by them *kaolin*, is a white, earthy ſubſtance, which they mix intimately with the ground petuntſe. Mr. Reaumur examined both theſe matters, and having expoſed them ſeparately to a violent fire, he diſcovered that the petuntſe had fuſed without addition, and that the kaolin had given no ſign of fuſibility. He afterwards mixed theſe matters, and formed cakes of them, which by baking were converted into porcelain ſimilar to that of China. Mr. Reaumur eaſily found that the petuntſe of the Chineſe was a hard ſtone of the kind called vitrifiable, but infinitely more fuſible than any of theſe which were known in Europe; and that the kaolin was a talky matter, reduced to very fine powder (*m*). From that time he hoped to make a porcelain of the ſame kind as the Chineſe with materials found in France. Whether he could not find any materials equal to thoſe of China, particularly that material analogous to the petuntſe of the Chineſe, or becauſe other occupations prevented the continuance of his reſearches, we do not know; but we find, from his ſecond Memoir upon porcelain, that he afterwards attempted to make an artificial petuntſe, by mixing our vitrifiable ſtones with ſalts capable of rendering them fuſible, or even by ſubſtituting for it glaſs ready formed, and by adding to theſe ſuch ſubſtances as he thought might be ſubſtituted for kaolin. But he probably found he could not execute theſe intentions, for he did not reſume this ſubject from the year 1729 to 1739,

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(*m*) The *petuntſe* is improperly ranked amongſt the claſs of earths called vitrifiable, becauſe it is fuſible without addition, and becauſe it is not hard enough to elicit ſparks from ſteel; whereas the vitrifiable or ſiliceous earths are unfuſible by fire, unleſs they contain ſome metallic mixture, and are very hard. Authors have not deſcribed very diſtinctly the petuntſe; ſome believing it to be an alkaline ſpar, and others the rhomboidal quartz, called *feldtſpar*. But from the later accounts, and from a knowledge of ſome experiments that have been made ſucceſsfully concerning porcelain, I believe that the petuntſe is different from both theſe ſubſtances, and that it is a white opake fluor. At leaſt I have ſeen excellent porcelain made with ſuch a fluor together with a white argillaceous earth. The texture of this fluor was laminated, its figure was indeterminate, it was rendered luminous in the dark by friction, it was fuſible by violent heat, it was not ſufficiently hard to elicit ſparks from ſteel, and it was indiſſoluble by acids. It ſeems to be of the ſame kind as the Bolognian ſtone, and the white heavy fluors, which, as Mr. Margraaf found, are capable of acquiring by calcination with inflammable matter the property of abſorbing light. *See* PHOSPHORIC STONES. Mr. Scheffer's examination of Chineſe petuntſe, publiſhed in the Swed. Tranſ. 1753, correſponds with the above account, excepting that his ſpecimen appears to have had a greater tranſparency than the fluor above deſcribed, and to reſemble the lapis ſpecularis, which alſo poſſeſſes the phoſphoric property of the Bolognian ſtone, and contains, according to Mr. Margraaf's experiments, nearly the ſame principles as that ſtone and the heavy white fluors above deſcribed. *See* PHOSPHORIC STONES. I do not, however, mean to affirm that no porcelain can be made without ſuch a fluor. I am inclined to believe that porcelains may be made of other materials beſides a clay or kaolin, and a white fluor or petuntſe. One of the ingredients of the Saxon porcelain is a beautiful white ſtone, which is not fuſible by a moſt violent heat. See Mr. D'Arcet's Memoir ſur l'Action d'un Feu Violent, &c. Mem. de l'Acad. des Sc. 1766. Pure clays ſingly, or mixed with finely-ground ſiliceous earth, acquire by violent heat the hardneſs and all the properties, excepting the ſemi-tranſparency, of porcelain.

The *kaolin* of the Chineſe is a white argillaceous earth, ſometimes intermixed with particles of mica, and, as Mr. Bomare affirms, ſometimes with particles of quartz and of calcareous earth. But the quantity of the laſt ſubſtance muſt be very ſmall, as it would render the argillaceous earth fuſible, and conſequently unfit for the purpoſe of a kaolin. Mr. Guettard, who has written a Memoir upon the ingredients of Porcelain (Mem. of the Acad. of Sciences, 1765) deſcribes the kaolin as a white argillaceous earth without any calcareous mixture. Probably the calcareous particles found in the ſpecimen analiſed by Mr. Bomare, and perhaps alſo the particles of quartz and of mica, are not neceſſary and conſtant parts of kaolin.

when he gave a proceſs for converting common glaſs to a ſingular kind of porcelain, to which he has given his name, and of which we ſhall treat in the following article.

Although Mr. Reaumur has not exhauſted entirely this ſubject, he has ſurmounted many difficulties, and has given juſt notions concerning it: In a word, he has opened the road for all thoſe who afterwards engaged in this purſuit, and has therefore a right to ſhare the honor of the important diſcoveries which have been ſince made by others.

But as a perſon who firſt unravels ſo intricate and hidden a matter as the manufacture of porcelain, can ſcarcely diſcover every thing concerning his ſubject, ſo Mr. Reaumur has been miſtaken, or rather miſled in two important points. His firſt error concerns the Saxon porcelain, which he confounds with the other fuſible porcelains made in Europe. I do not know whether formerly a porcelain was made in Saxony, compoſed entirely of fuſible or vitrifiable materials, the vitrification of which was ſtopt in proper time. Poſſibly this was the firſt kind of porcelain made in that country, and which Mr. Reaumur had examined. But I am certain that I have never ſeen any ſuch Saxon porcelain, and that all of that country which I have examined was capable of reſiſting the moſt violent fires without fuſion, as well, at leaſt, as thoſe of China and Japan. Mr. Reaumur might have been miſled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal ſurface does not appear granulous, but compact, uniform, ſmooth, ſhining, and much reſembling white enamel. But this appearance, ſo far from ſhewing that Saxon porcelain is a fuſed or vitrified ſubſtance, proves that it is not entirely compoſed of fuſible matters. All who have conſidered attentively this ſubject know that the internal ſurface of the moſt fuſible porcelains is alſo the leaſt denſe and leaſt compact: the reaſon of which is, that no vitreous matter can be ſmooth and denſe internally, unleſs it has been completely fuſed. But if the denſity and ſhining appearance of the internal ſurface of the Saxon porcelain were only the effects of the fuſion of a vitreous matter, how could we conceive that veſſels formed of that matter ſhould have ſuſtained the neceſſary fuſion for giving this denſity and ſhining appearance, without having entirely loſt their ſhape? The impoſſibility of this is evident to any perſons who have been converſant in theſe matters, and in the fuſion of glaſs.

This quality of the Saxon porcelain muſt therefore proceed from another cauſe. It does indeed contain, as every porcelain does, particularly thoſe of China and Japan, a fuſible ſubſtance, which has been even completely fuſed during the baking. Its denſity alſo and its internal luſtre proceed chiefly from this fuſed matter; but we are alſo certain that it contains a large quantity of a ſubſtance abſolutely unfuſible, from which it receives its admirable whiteneſs, its firmneſs and ſolidity, during the baking; in a word, which ſupplies the place of the oriental kaolin, and which has the property of contracting its dimenſions conſiderably while it incorporates with the fuſible ſubſtance. If it be ſubjected to the moſt deciſive trial, namely, the action of a violent fire, capable of melting every porcelain compoſed of fuſible matters alone, I affirm, after many experiments, that it cannot be fuſed, unleſs by a fire capable alſo of melting the beſt Japaneſe porcelain. The Saxon porcelain is therefore not to be confounded with thoſe which are vitreous and fuſible, but is in its kind as excellent as that of Japan, and perhaps ſuperior, as we ſhall ſee when we enumerate the qualities which conſtitute the excellence of porcelain. The ſubject of Mr Reaumur's ſecond error, or, at leaſt, that which he has not ſufficiently explained, is the *kaolin* of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntſe, the oriental porcelain is formed. Poſſibly a very finely-ground talky ſubſtance mixed with petuntſe might form a porcelain ſimilar to the oriental; but perſons acquainted with the manuſacture of any porcelain, muſt perceive the impoſſibility of forming veſſels, unleſs the paſte of which they are made be ſo ductile and tenacious, that it may be worked upon a potter's lathe, or at leaſt that it may be moulded. But talks or any kinds of ſtones, however finely ground, cannot acquire the requiſite tenacity, which clays only, of all known earthy ſubſtances, poſſeſs. The Chineſe porcelain veſſels evidently appear to be turned upon the lathe, ſince they retain the marks of it; hence they muſt have been formed of a very tenacious paſte, and conſequently the kaolin is not a purely talky matter, but is mixed with clay; or elſe the petuntſe and kaolin are not, as Mr. Reaumur ſuppoſes, the only ingredients of the paſte of which Chineſe porcelain is formed, but a ſufficient quantity of ſome binding matter, unknown to father d'Entrecolles and Mr. Reaumur, muſt be alſo added.

Although, ſince Mr. Reaumur, no ſcientific perſon has written concerning porcelain, many have attempted to make it. Manufactures have been eſtabliſhed in almoſt all the ſtates of Europe. Beſides that of Saxony, which has been long eſtabliſhed, porcelain is alſo made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. All theſe German porcelains are ſimilar to the Saxon, and are made of materials of the ſame kind, although they differ ſomewhat from each other. England and Italy alſo have their porcelains, the chief of which are thoſe of Chelſea and of Naples. Mr. de la Condamine, in his laſt journey into Italy, viſited a manufacture of porcelain eſtabliſhed at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine obſerved particularly the large ſize of ſome pieces of this porcelain. He ſays he ſaw ſtatues and groupes half as large as nature, modelled from ſome of the fineſt antiques. The furnaces in which the porcelain was baked were conſtructed with much art, and lined with bricks made of the porcelain materials. The paſte of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the beſt Chineſe porcelain. A whiter glazing would be deſirable, which they might probably attain, if the Marquis Ginori was not determined to uſe thoſe materials only which were found in that country.

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porcelain of China and Japan in ſolidity, grain, and unfuſibility. It were to be wiſhed that it poſſeſſed equally the other qualities eſſential to the excellence of porcelain, namely, the whiteneſs and luſtre obſervable in the ancient Japaneſe porcelain (*p*).

We ſhall not here particularly examine the qualities of the ſeveral porcelains now known. We ſhall only ſhew what thoſe qualities are which conſtitute the perfection of porcelain. We muſt firſt carefully diſtinguiſh the qualities which only contribute to beauty and external appearance, from the intrinſic and eſſential properties in which the goodneſs and ſolidity of porcelain conſiſt. All perſons who have made experiments in this way have ſoon diſcovered the poſſibility of making compounds very white, beautifully ſemi-tranſparent, and covered with a ſhining glazing, but which cannot be worked for want of tenacity, are not ſufficiently compact, are eſſentially fuſible, are ſubject to break by ſudden application of heat and cold; and, laſtly, the glazing of which cracks, becomes rough, and conſequently loſes its luſtre by uſe, becauſe it is too ſoft.

On the other ſide, we ſhall alſo find it not difficult to compoſe very tenacious paſtes, which ſhall be capable of being eaſily worked and well baked, which in the baking ſhall acquire the deſirable hardneſs and denſity, which are unfuſible, and capable of ſuſtaining very well the ſudden change of heat and cold; and, in a word, which ſhall have all the qualities of the moſt excellent porcelain, excepting whiteneſs and beauty. We ſhall ſoon ſee that the materials fit for the compoſition of ſuch porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodneſs in one compoſition. I acknowledge that nature ſeems to be very ſparing of materials fit for this purpoſe, and therefore perfect porcelain will always be a dear and valuable commodity.

Many will be ſurprized when I affirm, that before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made here equal in goodneſs and in eſſential qualities, and was univerſally uſed and even ſold very cheap. For thoſe potteries which we call *grais* or *ſtone-ware* are not of modern invention, and have all the eſſential qualities of the beſt Japaneſe. For if we except whiteneſs, on which alone the ſemi-tranſparency depends, and compare all the properties of Japaneſe porcelain with thoſe of our ſtone-ware, no difference can be found betwixt them. The ſame grain appears internally in both; the ſame ſound is produced by ſtriking them when properly ſuſpended; the ſame denſity; the ſame hardneſs, by which they ſtrike fire with ſteel; the ſame faculty of ſuſtaining the heat of boiling liquors without breaking, and the ſame unfuſibility in fire, are obſervable. Laſtly, if the earths of which ſtone-ware is made were free from heterogeneous coloring matters, which prevent their whiteneſs and ſemi-tranſparency; if veſſels were carefully formed; if all the proper attentions were given; and if theſe veſſels were cover-

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(*p*) The porcelain made by that ingenious and ſcientific nobleman is ſaid to have poſſeſſed the intrinſic excellencies of porcelain, as eminently, at leaſt, as even the Saxon or oriental. A gentleman of undoubted veracity has aſſured me, that when the Count de Lauraguais was a few years ago in England, he ſaw him heat a piece of his porcelain till it was red-hot, and then throw it into cold water, without breaking or cracking it.

ed over with a fine glazing; they would be as perfect porcelain as that of Japan. The moſt perfect porcelain, therefore, is nothing elſe than a fine white ſtone-ware. (*q*)

Earths of this kind are probably more rare in Europe than in Japan and China. And probably alſo the want of theſe earths was the cauſe that the firſt makers of porcelain in this country confined themſelves to an external imitation, by employing nothing but vitrifiable matters with fuſible ſalts and a ſmall quantity of white earth, from which fuſible and vitreous porcelains were compoſed, which might be called *falſe porcelains*. But things are much changed ſince theſe firſt attempts Beſides the diſcoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains have been made a long time ago in Germany, eſpecially in Saxony and at Frankendal. The new porcelain, a trial of which is juſt finiſhed at the King's manufacture, is of this kind. (*r*)

Theſe porcelains are not inferior in any reſpect to the oriental; they are even much ſuperior in beauty and whiteneſs to the modern oriental porcelain, which has much degenerated in theſe reſpects; they ſeem even to excel the oriental in the moſt valuable quality of porcelain, namely, the property of ſuſtaining the ſudden change of heat and cold. We cannot judge of the quality of porcelain by a ſlight trial: for ſo many circumſtances concur to make a piece of porcelain capable or incapable of ſuſtaining the ſudden application of heat and of cold, that if at the ſame time boiling water be poured into two veſſels, one of which is good porcelain and the other bad, the former may poſſibly break, and the latter remain entire: the only true method of diſcovering good porcelain in this reſpect is, to examine ſeveral pieces of it which are daily uſed, for inſtance, a ſet of coffee-cups. But I have obſerved that in many ſuch pieces of oriental porcelain, which have been long and daily uſed, cracks in the direction of their height may be always perceived, which are never ſeen in the good European porcelains.

Every one talks of porcelain, and yet few are connoiſſeurs of it. None can be conſidered as ſuch but thoſe who have long made it an object of their inquiries. That the ancient Japaneſe porcelain is the moſt perfect, is a general opinion. This porcelain is indeed very beautiful, and we muſt alſo acknowledge that its quality is excellent. It has been our model, and has long been the object of our admiration and emulation; but which we have been never able to equal, and which many perſons believe never can be equalled. Some perſons even decry the Saxon porcelain for a quality which really gives it a ſuperiority to the Japaneſe, namely, the greater ſmoothneſs, luſtre, and leſs granulous appearance of its internal ſurface than the oriental. The reſemblance of this

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(*q*) The French ſtone ware, or *potterie de grais*, is formed of a whitiſh clay, in which a good deal of fine white ſandy particles are intermixed. The Engliſh *ſtone-ware* is compoſed of tobacco-pipe clay and ground flints. This ware, when ſufficiently burnt, has, as well as the French, the qualities of porcelain which the author calls eſſential, namely, ſtrength, hardneſs, the property of ſuſtaining the heat of boiling water, and unfuſibility. *See* FOTTERY.

(*r*) I have nevertheleſs ſeen ſeveral pieces of the porcelain of Sèvres, lately brought from thence, which were not of the kind called by the author *genuine*, but which had the properties and defects mentioned in the above note (*n*).

ſurface to that of glaſs has evidently ſuggeſted this notion; and it would be well founded, if the denſity and luſtre of this porcelain proceeded only from a fuſible and vitreous quality; but as they do not, and as this porcelain is as fixed and as unfuſible as the Japaneſe, its denſity, ſo far from being a fault, is a valuable quality. For we muſt allow, that of porcelains equal in other reſpects, thoſe are beſt which are moſt firm and compact. Hence, the interior ſubſtance of the Japaneſe porcelain is eſteemed for its greater denſity, compactneſs and luſtre, than our vitreous or fritt porcelains, becauſe theſe qualities indicate greater coheſion, and more intimate incorporation of its parts. For the ſame reaſon alſo the ſuperior denſity of the Saxon porcelain ought to give it the preference to the Japaneſe. Beſides, nothing would be eaſier than to give the Saxon porcelain the granulous texture of the Japaneſe, by mixing with the paſte a certain quantity of ſand. But the perſons who perfected that manufacture were certainly ſenſible, that ſuch a conformity to the Japaneſe porcelain would leſſen the merit of theirs. For we know, that in general porcelains are better in proportion as they contain a larger proportion of clay or earth, and leſs of ſand, flints, or other matters of that kind.

What we have ſaid concerning porcelain in general, and the principal kinds of it, ſeems ſufficient to give juſt notions of it, if not to perſons who without conſidering the ſubject are determined to prefer the moſt ancient, to thoſe, at leaſt, who have made experiments on this ſubject, or who, having a ſufficient knowledge of chemiſtry, are capable of ſtudying and examining it thoroughly. We ſhall finiſh this article by giving a ſhort deſcription of the method of manufacturing porcelain.

The baſis of the porcelains which we have called fuſible, vitreous, or falſe porcelains, is called by artiſts a *fritt*; which is nothing elſe than a mixture of ſand or of powdered flints, with ſalts capable of diſpoſing them to fuſion, and of giving them a great whiteneſs by means of a ſufficient heat. This fritt is to be then mixed with as much, and no more, of a white tenacious earth, of an argillaceous or marly nature, than is ſufficient to make it capable of being worked upon the wheel. The whole mixture is to be well ground together in a mill, and made into a paſte, which is to be formed, either upon the wheel or in moulds, into pieces of ſuch forms as are required.

Each of theſe pieces when dry is to be put into a caſe made of earthen ware (*s*); which caſes are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with theſe to the roof. The furnaces are chambers or cavities of various forms and ſizes, and are ſo diſpoſed that their fire-place is placed on the outſide oppoſite to one or more openings, which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying, determines a current of air from without inwards, as in all furnaces. At firſt a very little fire is made, that the furnace may be heated gradually, and is to be encreaſed more and more, till the porcelain is baked,

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(*s*) The caſes are called by Engliſh potters, *ſeggars* They are generally formed of coarſer clays, but which muſt be alſo capable of ſuſtaining the heat required without fuſion. By means of theſe caſes, the contained porcelain is preſerved from the ſmoke of the burning fuel. The whiteneſs of the porcelain depends much on their compactneſs of texture by which the ſmoke is excluded, and on the purity of the clay of which they are made.

that is, till it has acquired its proper hardneſs and tranſparency; which is known by taking out of the furnace from time to time, and examining, ſmall pieces of porcelain, placed for that purpoſe in caſes which have lateral openings. When theſe pieces ſhew that the porcelain is ſufficiently baked, the fire is no longer to be ſupplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this ſtate reſembles white marble not having a ſhining ſurface, which is afterwards to be given by covering them with a vitreous compoſition, called the *glazing*.

The porcelain when baked and not glazed is called *biſcuit*, which is more or leſs beautiful according to the nature of the porcelain. The manufacture of Sévres excells all others in this reſpect, and it is therefore the only one which can produce very fine pieces of ſculpture; that is, in which all the fineneſs of the workmanſhip is preſerved, and which are preferable in ſmoothneſs and whiteneſs to the fineſt marble of Italy.

If this porcelain had no other merit, it would be ſufficient to induce true connoiſſeurs to prefer it to any other matter, however ſolid, without this advantage.

As no piece of ſculpture of this kind can preſerve all the delicacy of its workmanſhip when covered with a glazing; and as ſculptors avoid poliſhing their marble figures, becauſe the luſtre of the poliſh is diſadvantageous; therefore in the manufacture of Sévres, all figures, or little ſtatues, and even ſome ornamental vaſes, are left in ſtate of biſcuit. The other pieces of porcelain are to be glazed in the following manner.

A glaſs is firſt to be compoſed ſuited to the nature of the porcelain to which it is to be applied, for every glaſs is not fit for this purpoſe. We frequently find that a glaſs which makes a fine glazing for one porcelain ſhall make a very bad glazing for another porcelain, ſhall crack in many places, ſhall have no luſtre, or ſhall contain bubbles. The glazing then muſt be appropriated to each porcelain, that is, to the hardneſs and denſity of the ware, and to the ingredients of its compoſition, &c.

Theſe glazings are prepared by previouſly fuſing together all the ſubſtances of which they conſiſt, ſo as to form vitreous maſſes. Theſe maſſes are to be ground very finely in a mill. This vitreous powder is to be mixed with a ſufficient quantity of water, or other proper liquor, ſo that the mixture ſhall have the conſiſtence of cream of milk. The pieces of porcelain are to be covered with a thin ſtratum of this matter, and when very dry they are to be again put into the furnace, in the ſame manner as before, for the forming of the biſcuit, and to be continued there till the glazing be well fuſed. The neceſſary degree of fire for fuſing the glazing is much leſs than that for baking the paſte.

The pieces of porcelain which are intended to remain white are now finiſhed; but thoſe which are to be painted and gilded muſt undergo further operations. The colors to be applied are the ſame as thoſe uſed for enamel painting. They all conſiſt of metallic calxes bruiſed and incorporated with a very fuſible glaſs. Crocus of iron furniſhes a red color: Caſſius's precipitate of gold makes the purple and violet; copper calcined by acids and precipitated by an alkali gives a fine green; zaffre makes the blue; earths ſlightly ferruginous produce a yellow; and, laſtly, brown and black colors are produced by calcined iron, together with a deep blue of zaffre. Theſe colors being ground with gum-water, or with oil of ſpike, are to be employed for the painting of the porcelain with deſigns of flowers and other figures *(t)*. For gilding, a powder or calx of gold is to be applied in the ſame manner as the colored enamels *(u)*. The painted and gilded porcelains are to be then expoſed to a fire capable of fuſing the glaſs, with which the metallic colors are mixed. Thus the colors are made to adhere, and at the ſame time acquire a gloſs equal to that of the glazing. The gold alone has not then a ſhining appearance, which muſt be afterwards given to it by burniſhing with a blood-ſtone.

The operations for the unfuſible porcelains, and alſo for ſuch as are of the nature of ſtone-ware, are ſomewhat more ſimple. The ſands and ſtones which enter into their compoſition are to be ground in a mill: the earths or clays are to be waſhed: the materials are to be well mixed and formed into a paſte: the pieces are firſt rudely formed upon a potter's wheel; and when dry or half dry, they are turned again upon the wheel, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a ſufficient heat to give them ſuch a ſolidity that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this ſlight heat are very dry, they imbibe water readily. This diſpoſition aſſiſts the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previouſly ground in a mill, is to be mixed with ſuch a quantity of water, that the liquor ſhall have the conſiſtence of milk. The pieces of porcelain are haſtily dipt in this liquor, the water of which they imbibe, and thus on their ſurface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very ſoon become ſo dry, that it cannot ſtick to the fingers when the pieces are handled.

The pieces of this porcelain are then put into the furnace to be perfectly baked. The heat is to be raiſed to ſuch a height, that all within the furnace ſhall be white, and the caſes ſhall be undiſtinguiſhable from the flame. When, by taking out ſmall pieces, the porcelain is known to be ſufficiently baked, the fire is diſcontinued, and the furnace cooled. If the baking has been well performed, the pieces of porcelain will be found by this ſingle operation to be rendered compact, ſonorous, cloſe-grained, moderately gloſſy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner ſimilar to that already deſcribed. *(x)*

(t) *See the article* ENAMEL, *and the* Note *ſubjoined.*

(u) The ſeveral powders of gold employed for this purpoſe are deſcribed in a note ſubjoined to the article GILDING.

(x) I purpoſely avoid giving any opinion concerning the relative advantages and defects of the porcelains of British manufacture. I ſhall only add, that we have reaſon to believe, that the materials of genuine porcelain might be diſcovered in this iſland, if ſearch were made by intelligent perſons. The ſteatites or ſoap-rock of Cornwall is probably a good *kaolin*; and I have ſometimes found ſtones in England in which the white opake fluor above deſcribed was blended with a pure quartz, and which I am well convinced might be ſucceſsfully employed as a *petuntſe*. With pleaſure I hear that an ingenious gentleman has found a true kaolin and petuntſe in Devonſhire and Cornwall, and that he has lately eſtabliſhed a manufactory of genuine porcelain. It is to be hoped that he may ſucceed in the introduction of this very elegant and uſeful manufactory:

DXLVIII. PORCELAIN *of* MR. REAUMUR. Mr. Reaumur having made many experiments to diſcover the nature of the materials which enter into the compoſition of the oriental porcelain, and having aſcertained that all porcelain is an intermediate ſubſtance betwixt an earth and glaſs, very ingeniouſly thought of reducing glaſs ready made to the ſtate of porcelain, by undoing the vitrification, or partly unvitrifying it: hence this kind of ware has been called *porcelain unvitrified.* Mr. Reaumur gave the quality of porcelain to glaſs; that is, he rendered glaſs of a milky color, ſemi-tranſparent, ſo hard as to ſtrike fire with ſteel, unfuſible, and of a fibrous grain, by means of cementation. The proceſs which he publiſhed is not difficult. Common glaſs, ſuch as that of which wine-bottles are made, ſucceeds beſt. The glaſs-veſſel which is to be converted into porcelain is to be encloſed in a baked earthen caſe or ſegger. The veſſel and caſe are to be filled with a cement compoſed of equal parts of ſand and powdered gypſum or plaſter; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glaſs veſſel will be found transformed into ſuch a matter as we have deſcribed.

This kind of porcelain has not a very white color, particularly on its ſurface; but for ſome purpoſes it may be uſeful, eſpecially for chemical veſſels. Mr. Reaumur has not explained how this transformation is effected. The cauſe of it probably is, that the vitriolic acid of the gypſum quits its baſis of calcareous earth, and unites with the alkaline ſalt and ſaline earth of the glaſs, with which it forms a kind of ſalt or ſelenites different from the calcareous ſelenites, by the interpoſition of which matter the glaſs acquires the qualities of porcelain. (y)

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and although many and great difficulties, beſides the diſcovery of proper materials, muſt occur in the execution of that work, yet theſe are not inſuperable.

(y) Mr Reaumur ſays, that glaſs thus rendered opake, white, unfuſible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every eſſential quality of porcelain it is equal to any, and even ſuperior in the property of ſuſtaining alterations of heat and cold.

The character given by Mr. Reaumur of this porcelain induced Dr. Lewis (who had alſo obſerved the changes produced upon glaſs-retorts expoſed to violent heat in a ſand-bath) to make further experiments on this matter, an account of which he has publiſhed in the *Philoſophical Commerce of Arts*, a work which we much wiſh to ſee proſecuted in the ſame able and uſeful manner in which it has been begun.

From Dr. Lewis's experiments we find the following reſults. 1. Green glaſs cemented with white ſand received no change in a heat below ignition. In a low red-heat the change proceeded exceeding ſlowly; and in a *ſtrong red-heat*, approaching to whiteneſs, the thickeſt pieces of glaſs bottles were thoroughly converted in the ſpace of three hours. 2. The glaſs ſuffered the following *progreſſion of changes* by continued heat: Firſt, its ſurface became blue, its tranſparency was diminiſhed, and a yellowiſh hue was obſervable when it was held between the eye and the light. Afterwards it was changed a little way on both ſides into a white ſubſtance, externally ſtill bluiſh; and as this change advanced ſtill further and further within the glaſs, the color of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were diſpoſed nearly parallel to one another, and tranſverſe to the thickneſs of the piece: by degrees the glaſs became throughout white and fibrous, the external bluiſhneſs at the ſame time going off, and being ſucceeded by a dull whitiſh or dun color: by a ſtill longer continuance in the fire the fibres were changed gradually from the external to the internal part, and con-

DXLIX. PORPHYRY. (z)

DL. POTASH. *See* ALKALI (FIXED).

DLI. POTTERY. The art of making pottery is intimately connected with chemiſtry, not only from the great uſe made of earthen veſſels by

chemiſts,

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verted into grains; and the texture then was not unlike that of common porcelain. The grains, at firſt fine and ſomewhat gloſſy, appeared afterwards larger and duller, and at length the ſubſtance of the glaſs became porous and friable, like a maſs of white ſand ſlightly cohering. 3. Concerning the *qualities* of the converted glaſs Dr. Lewis obſerves, that the whiteneſs of the internal part was not inferior to that of porcelain, but that its ſurface was the leaſt beautiful, that the thick pieces were quite opake, and that ſeveral thin pieces were ſemi-tranſparent: that while it remained in a fibrous ſtate, its hardneſs became greater than that of glaſs, or of the common kinds of porcelain; it was capable of ſuſtaining ſudden changes of heat and cold better than any porcelain; and in a moderate white heat, it was fuſible into a ſubſtance not fibrous, but vitreous and ſmooth, like white enamel: that when its texture had become coarſely granulated, it was now much ſofter and unfuſible: and, laſtly, that when ſome coarſely granulated, unfuſible pieces which, with the continuance of a moderate heat, would have become porous and friable, were ſuddenly expoſed to an intenſe fire, they were rendered remarkably more compact than before; the ſolidity of ſome of them being ſuperior to that of any other ware. 4. No differences appeared in the internal color, hardneſs, texture, or the regular ſucceſſion of changes, from the uſe of *different cementing ſubſtances*; though in external appearances the differences were conſiderable. All the pieces which had been ſurrounded with charcoal or with ſoot were externally of a deep black color, which did not diſappear by expoſure to a ſtrong fire during an hour, with free acceſs of air. Colored clays and ſands communicated different ſhades of a brown color; and white earths gave whitiſh, greyiſh, or browniſh tinges. White ſand, calcined flints, and gypſum, gave in general the greateſt whiteneſs, and tobacco-pipe clay the greateſt gloſſineſs and brightneſs. 5. Glaſſes compoſed of earths without alkaline ſalt, glaſs of lead, flint-glaſs, crown-glaſs, looking-glaſs plates, a glaſs prepared with calcined flints and a fixed alkaline ſalt, and even green glaſs which had been fuſed together with a ninth part of alkaline ſalt, ſuffered none of the above alterations by cementation. Green bottle-glaſs and common window-glaſs were moſt ſuſceptible of theſe alterations. 6. The changes produced by cementation could not proceed from any abſorption of matter from the cementing ſubſtance; becauſe no increaſe of weight was given, and becauſe the ſame changes were produced upon a piece of glaſs merely by heat, without any cementing ſubſtance. The real *cauſe of theſe changes* ſeems to be, that a part of the alkaline ſalt of the glaſs, to which the vitrified ſtate of the earth is owing, exſudes by heat, and is imbibed by the ſurrounding matters, as appears from the concretion obſervable in theſe matters after a long cementation. Thoſe glaſſes only are ſuſceptible of change which contain but a ſmall quantity of alkaline ſalt; becauſe no more of this ſalt being contained than is neceſſary to give a vitrified ſtate to the earth, any exſudation of it muſt in ſome meaſure unvitrify the glaſs, and approximate it more and more to the ſtate of the earth of which it was formed. Perhaps alſo the firſt degree of change may partly depend on an alteration produced by the heat in the glaſs itſelf conſidered as a compound, or in the nature of its alkaline ingredients, which we know are liable, by expoſure to fire, to loſe ſomething of their ſaline nature, and to be partly changed to earths.

(z) PORPHYRY is a compound ſtone conſiſting of Jaſper, in which particles of feltſpar, and ſometimes of mica and baſaltes, are interſperſed. Its colors are green, red, black, brown, or dark-grey, varying according to the color of the jaſper which is the baſis of this compound ſtone, and of the quantity and colors of the interſperſed particles. Porphyry is generally fuſible by fire. Its fuſibility is probably owing to the metallic matter with which the jaſper is tinged, and to the baſaltes or other fuſible particles intermixed. The ſurface of this ſtone is generally covered with a whitiſh cruſt.

chemiſts, but alſo becauſe all the proceſſes of this art, and the means of perfecting it, are dependent on chemiſtry. We muſt, however, acknowledge, that although chemiſts have moſt intereſt to procure good crucibles and other earthen veſſels, this art has been left almoſt entirely to the potter. Mr. Pott is the firſt and the only chemiſt who has attended to this object. Beſides many experiments related in his Lithogeognoſia, from which much inſtruction may be received relating to the perfection of chemical veſſels, he has written a treatiſe expreſsly on this ſubject, in which he gives many compoſitions for crucibles, the chief of which ſhall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths; becauſe theſe earths are capable of being kneaded, of eaſily receiving any form, and of acquiring much ſolidity and hardneſs by expoſure to fire. But clays differ much in the effects produced upon them by fire. Some clays, which are of the pureſt kind, reſiſt the moſt violent fire without receiving any other change than a conſiderable hardneſs; but ſtill they are not rendered ſo hard and compact as other clays. A ſecond kind of clays by expoſure to violent heat acquires a hardneſs equal to that of flints, and a texture compact and gloſſy, like that of good porcelain; but they are nevertheleſs unfuſible by the moſt violent heat. Theſe qualities are occaſioned by ſome fuſible materials being mixed with them, as ſand, chalk, gypſum, or ferruginous earth, which are in too ſmall a quantity to effect a compleat, but only a beginning or partial fuſion. Laſtly, a third kind of clays is firſt hardened by fire, and afterwards is compleatly fuſed. This laſt kind of clay evidently contains the largeſt quantity of the fuſible matters above-mentioned.

From the properties of theſe three principal clays we may conclude, that from clays alone three principal kinds of pottery may be produced. With the firſt kind of clay, pots or crucibles may be formed capable of ſuſtaining the moſt violent fire without fuſion, of containing melted metals, and even hard glaſſes not too fluid; but which, from want of ſufficient compactneſs, are incapable of containing during a long time in fuſion very fuſible ſubſtances, ſuch as nitre, glaſs of lead, glaſſes containing much arſenic, &c. by which ſubſtances their pores are pervaded. Theſe clays are employed advantageouſly for the formation of large pots or crucibles uſed in glaſs-houſes for containing hard glaſs, as bottle-glaſs.

With clays of the ſecond kind may be made crucibles and other potteries, commonly called ſtone-ware. Potteries made with theſe earths, when ſufficiently baked, are very ſonorous, ſo hard as to ſtrike fire with ſteel, capable of containing all liquids, of which the former kind, from their poroſity, are incapable, and even reſiſt the action of nitre, glaſs of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardneſs and denſity, which prevents their ſudden expanſion and contraction, by the haſty application of heat and cold, makes them liable to break in all operations where they are ſuddenly expoſed to heat or to cold, as, for inſtance, in a furnace through which a ſtrong current of air paſſes. If this kind of pottery had not this inconvenience, it would be the beſt and moſt perfect for the purpoſes of ordinary life and chemiſtry. Notwithſtanding this inconvenience, this is the only pottery that is applicable in many occaſions; and then all poſſible care muſt be taken to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

Laſtly, with fuſible clays may be made many kinds of veſſels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but ſlightly baked; hence its texture is coarſe and porous. Some utenſils are made of this pottery without glazing, as foot-ſtoves, &c. But in general they are covered with a glazing, without which water or other liquids would paſs through their pores. Some of this pottery, which is finiſhed with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called Delf Ware, *which ſee.* Other coarſer potteries of this kind are glazed with glaſs of lead mixed with metallic calxes, or fuſible colored earths, from which they receive various colors. This is the ordinary pottery.

Laſtly, a fine kind of pottery is made of white clays, or of ſuch as whiten in the fire, the ſurface of which is vitrified by throwing into the furnace, when the ware is ſufficiently baked, ſome common ſalt and ſalt-petre. This pottery is called *Engliſh-ware,* becauſe the firſt and beſt was made in England. True, white Engliſh ware is not without merit; it is white, fine, well baked, and has ſome ſmall degree of tranſparency when thin; ſo that it is intermediate betwixt porcelain and common ſtone-ware, and may therefore be called a ſemi-porcelain. *(a)*

Some of theſe potteries can ſuſtain a ſudden application of heat and of cold, ſufficiently well for the uſes of a kitchen, and are therefore called *fire-ware:* but theſe are always the coarſeſt, leaſt baked, and the glazing of which is the ſofteſt. They alſo do not laſt long when much uſed; for it is a chimera to ſuppoſe, as ſome perſons do, that pottery may be made capable of ſuſtaining fire like a metal veſſel. We are certain that the beſt of this kind which are employed for this purpoſe, break as ſoon as they are put upon the fire. They do not break ſo as to ſeparate in pieces, or even to let liquors paſs through them; but many ſmall cracks are formed; which we may be aſſured of by the crackling heard upon their being firſt ſet on the fire, by the many cracks which may be perceived in their glazing, and by their ceaſing to ring when ſtruck, after they have been once heated. Each time that theſe veſſels are ſet on the fire, many ſmall imperceptible cracks are formed in them, which by frequent uſe become ſo numerous, that the veſſel may be broken by the leaſt force. Thus all the difference betwixt the potteries which are intended to be uſed on the fire and the good ſtone-ware which is not intended for that purpoſe is, that this latter kind may be broken at once, when heated and cooled careleſsly, whereas the former is broken by degrees. Nevertheleſs, this fire-ware is uſeful, as it can ſerve for a ſhort time.

(a) I have never ſeen any Engliſh ſtone-ware that had the ſemi-tranſparency and whiteneſs mentioned by the author. As the Engliſh ſtone-ware is compoſed of tobacco-pipe clay and ground flints, both which ſubſtances are perfectly unfuſible, ſingly, or jointly, it cannot poſſeſs any degree of tranſparency. The uſe of the flints is to give ſtrength to the ware, ſo that it ſhall preſerve its form during the baking: whereas veſſels made of clay alone, although unfuſible by fire, and capable of acquiring, by having been expoſed to an intenſe heat, the hardneſs of the beſt porcelain; while they are hot, are ſoft, ſink by their weight, ſo as to loſe the form given to them. This ſtone-ware is glazed in the manner mentioned by the author, but by means of common ſalt only, without any mixture of nitre. This glazing has not the beauty or ſmoothneſs of good vitreous glazings. Another kind of ſtone-ware, called *Queen's ware,* is made in England, and lately much uſed. It is compoſed of the ſame materials as the former, but with a leſs proportion of flints, as it is to be expoſed to a leſs violent heat than the former ware; the vitreous glazing with which it is covered not being capable of ſuſtaining ſuch heat. Its color is leſs white than that of the former, having a yellowiſh tinge; but the ware is preferred on account of the ſmoothneſs of its glazing and neatneſs of its forms.

We ſhall not deſcribe the operation of making pottery, becauſe we have already ſpoken of it under the articles DELF-WARE *and* PORCELAIN, from which the common ware only differs, with regard to its manufacture, in its greater ſimplicity. We ſhall here add ſome obſervations concerning chemical veſſels, as retorts, muffles, and crucibles.

All the operations where great heat is employed require veſſels of baked earth; becauſe theſe alone can ſuſtain at once the action of violent fire and of chemical ſolvents. Veſſels made of good baked clay eminently poſſeſs theſe two qualities, and are the beſt which can be employed in chemiſtry; but as they have the inconvenience of breaking by ſudden application of heat and cold, and as many operations do not require veſſels ſo denſe, mixtures of earth have been uſed, of which crucibles are made, capable of being made ſuddenly red-hot, and ſuddenly cooled without breaking, and ſufficiently denſe to contain metals and other matters in fuſion during a long time. The beſt crucibles of this kind are brought from Heſſe, in Germany. Theſe crucibles are made with a good refractory clay, mixed, according to Mr. Pott, with two parts of ſand, of a middling fineneſs, from which the fineſt part has been ſifted. The mixture of ſand with clay produces two good effects; the firſt, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it ſuſtains during its drying; and, ſecondly, to prevent its acquiring too great cloſeneſs and compactneſs of texture by being baked. Thus we obtain crucibles moderately denſe, capable of containing metals and other things in fuſion, and infinitely leſs ſubject to break by heat and cold than thoſe made of pure clay.

The particles of the ſand mixed with clay in this compoſition for crucibles ought to be rather of a moderate ſize than very fine; becauſe, as Mr. Pott remarks, the former renders the crucibles much leſs apt to crack than the latter. In the ſecond place, that chemiſt forbids the uſe of ſand, flints, or other earths of that kind in the compoſition of crucibles intended to contain glaſſes or vitrifying matters a long time in fuſion; becauſe theſe vitreous matters act upon ſand, flints, and all thoſe called vitrifiable earths; by which means theſe crucibles are ſoon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of ſand are procured by ſubſtituting to the ſand a good baked clay in groſs powder. In this manner are made the pots which contain the vitrifiable materials in glaſs-houſe furnaces, ſome of which reſiſt the continued fires employed there during three weeks or a month (*b*). The quantity of burnt clay

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(*b*) The pots uſed in glaſs-houſes frequently ſuſtain a conſtant fire during ſeveral months, and ſometimes even a year. They become gradually more and more thin, the glaſs or flux contained probably diſſolving them thus ſlowly.

in the compoſition for crucibles varies in proportion to the nature of the crude clay, from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the ſtronger, more tenacious, and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are compoſed on the ſame principles. They are made of clay mixed with broken butter-pots, which are a ſtone-ware made in Normandy and Piccardy. Theſe crucibles reſiſt admirably well ſudden heat and cold, and they would be excellent if the crude clay which enters into their compoſition was capable of reſiſting a violent fire: but this clay being mixed with martial and pyritous matters ſwells in the fire, and begins to melt. Beſides, theſe crucibles owe their good quality of not breaking by ſudden application of heat and cold to their little denſity, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may, from what has been ſaid, perceive the difficulty, perhaps the impoſſibility, of making perfect crucibles. Mr. Pott has made ſo many experiments on this ſubject, that he ſeems to have exhauſted it. The baſis of all his compoſitions was clay; but this he mixed in different proportions with metallic calxes, calcined bones, calcareous ſtones, talks, amianthus, aſbeſtus, pounce-ſtones, tripoli, and many others, from none of which did he obtain a perfect compoſition, as may be ſeen from his Diſſertation: hence we conclude, that we muſt have in our laboratories crucibles of different kinds ſuitable to the ſeveral operations; Paris crucibles, when the matters contained are not too fluid, and the fire is not too ſtrong; Heſſian crucibles, when ſimilar matters are to be expoſed to a violent heat; and crucibles of baked clay for vitreſcent matters and penetrating fluxes.

Crucibles may poſſibly be made better than any hitherto known, and of more extenſive uſe. The eſſential point is to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the ſand muſt be waſhed. This muſt be mixed with two or three parts of the ſame clay baked and pounded groſsly; and of this mixture or paſte crucibles muſt be formed in moulds, and baked in a very ſtrong fire. As retorts and cucurbits are deſigned for the diſtillation of liquors generally very corroſive and penetrating, they ought to be made of ſtone-ware. (c)

(c) To what the Author of the Dictionary has ſaid concerning *crucibles*, I ſhall add ſome farther extracts from Mr. Pott's *Diſſertation* above-quoted.

1. Crucibles made of fat clays are more apt to crack, when ſuddenly expoſed to heat, than thoſe made of lean or meagre clays. *Meagre clays* are thoſe in which a conſiderable quantity of ſand is mixed with the pure argillaceous earth, and *fat clays* are thoſe which contain but a ſmall proportion of ſand. 2. Some crucibles become porous by long expoſure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external ſurfaces, which may be done by moiſtening theſe with oil of tartar, or by ſtrewing upon them when wetted with water, powdered glaſs of borax. Theſe glazings are not capable of containing glaſs of lead. 3. Crucibles made of burnt clay *groſsly powdered*, together with unburnt clay, were much leſs liable to crack by heat than crucibles made of the ſame materials, but in which the burnt clay was *finely powdered*, or, than crucibles made entirely of unburnt clay. 4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of groſsly powdered burnt clay, and three drams of calcined vitriol, are capable of retaining melted metals,

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DLII. POWDER. This name is given in general to all dry ſubſtances when divided into very ſmall parts. As in many chemical operations the ſubſtances employed muſt be neceſſarily reduced into very fine powder, different methods have been invented for this purpoſe according to the nature of the ſubſtances to be powdered. *See* DIVISION.

In pharmacy many remedies are in form of powder, and which are called *powders*; but theſe do not belong to our ſubject. Some chemical preparations and mixtures are known by the name of powder, as the *powder of Algaroth*, *gun-powder*, *fulminating powder*, of all which we ſhall treat.

DLIII. POWDER *of* ALGAROTH. This preparation, called alſo *emetic powder* or *mercurius vitæ*, is a kind of calx of regulus of antimony, ſeparated from the butter of antimony by water alone.

The marine acid, which cannot be united to the regulus of antimony but by particular proceſſes and when it is highly concentrated, as we ſee from the operation of butter of antimony, is much diſpoſed to ſeparate from it; and accordingly is ſeparated, at leaſt the greateſt part of it is ſeparated, by dilution with a ſufficient quantity of water. When therefore water is poured upon butter of antimony, the ſame thing happens as when water is mixed with the ſaline combination of the vitriolic acid with mercury; that is, the greateſt part

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but are pervaded by glaſs of lead. The following compoſition is as good or better than the preceding. Seven ounces of unburnt clay, fourteen ounces of groſsly powdered burnt clay, and one dram of calx of vitriol. Theſe crucibles may be rendered more capable of containing glaſs of lead, by lining their internal ſurfaces, before they are baked, with unburnt clay diluted with water. They may be further ſtrengthened by making them thicker than is uſually done, or by covering their external ſurfaces with ſome unburnt clay, which is called *arming* them. 4. The compoſition of which crucibles the moſt capable of containing glaſs of lead were made, was eighteen parts of groſsly powdered burnt clay, as much unburnt clay, and one part of fuſible ſpar. Theſe crucibles muſt not, however, be expoſed too ſuddenly to a violent heat. 5. Crucibles capable of containing very well glaſs of lead were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. Theſe required to be armed. 6. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal ſurface of a Heſſian crucible, rendered it capable of containing glaſs of lead during a long time. 7. One part of clay and two parts of Spaniſh chalk made good crucibles. The ſubſtance called Spaniſh chalk is not a calcareous earth, but appears to be a ſteatites. 8. Two parts of Spaniſh chalk and one part of powdered tobacco-pipes made a good compoſition for lining common crucibles. 9. Eight parts of Spaniſh chalk, as much burnt clay, and one part of litharge, made ſolid crucibles. 10. Crucibles made of black-lead are fitter than Heſſian crucibles for the melting of metals; but they are ſo porous, that fuſed ſalts paſs entirely through them. They are more tenacious than Heſſian crucibles, are not ſo apt to burſt in pieces, and are more durable. 11. Crucibles placed with their bottoms upwards are leſs apt to be cracked during the baking than when placed differently. 12. The paſte of which crucibles are made ought not to be too moiſt, elſe when dried and baked they will not be ſufficiently compact: hence they ought not to be ſo moiſt as to be capable of being worked on a potter's lathe, but they muſt be formed in braſs or wooden moulds. *See Mr. Pott's Diſſertation on Chemical Veſſels.*

Mr. Scheffer ſays, that the beſt crucibles cannot eaſily contain metals diſſolved by ſulphur, in the operation of parting by means of ſulphur. *See* PARTING. He ſays, that they may be made much more durable and ſolid, by ſteeping them a few days in linſeed oil, and ſtrewing powdered borax upon them before they are dried. *Mem. Sued.* xiv. 1752.

of the regulus of antimony is ſeparated from the marine acid, or at leaſt it retains too little of this acid to continue ſoluble, but is ſeparated in form of a white precipitate, while the reſt of the regulus remains diſſolved in water by means of the ſuperabundant acid.

The acid liquor in which the precipitate or powder of algaroth is formed has been called by the ancient chemiſts, very improperly, the philoſophical ſpirit of vitriol; for it does not contain an atom of vitriolic acid. We muſt not believe that it is pure marine acid, for it retains, as we have ſaid, a ſmall portion of the regulus of antimony; the proof of which is that this earth may be precipitated and rendered ſenſible by an alkali.

The earth thus precipitated by water from butter of antimony, after it has been frequently and perfectly waſhed with much diſtilled water, is called *powder of Algaroth*, from the name of a phyſician who uſed it as a remedy. This preparation of antimony given in doſes from a grain to three or four grains is a powerful emetic and purgative; but unconſtant in its effects, and even dangerous, as all the preparations of antimony are which are not in a ſaline ſtate.

Moſt chemiſts believe that the powder of algaroth retains a part of the acid of butter of antimony, and attribute its effects partly to this acid. When this powder has not been perfectly waſhed, it does indeed retain ſome acid, which may give it a degree of cauſticity. But we are not certain that all the acid cannot be waſhed from it by much water, or by being boiled in a large quantity of water. Mr. Beaumé pretends that it is very poſſible; but however well waſhed this powder may have been, it ſtill preſerves an emetic quality, nearly as great as that of glaſs of antimony; which is not ſurpriſing. For if we ſuppoſe that this antimonial earth was abſolutely deprived of acid, yet as it was combined with the marine acid, which does not deprive metals of all their phlogiſton, it retains enough of this principle to poſſeſs an emetic quality, as in general all antimonial calxes do when not perfectly dephlogiſticated.

Lemery ſays, that the powder of algaroth cannot be diſſolved either by ſpirit of nitre or by ordinary aqua regia, but that it is ſoluble by a mixture of the ſpirit of nitre, of ſea-ſalt, and of vitriol. As that chemiſt is very accurate, what he ſays is probably true. I ſhall nevertheleſs obſerve, that I have diſſolved this powder perfectly and entirely with cream of tartar, in the uſual manner of diſſolving glaſs of antimony in the preparation of emetic tartar, and thus obtained a neutral cryſtallizable ſalt. This experiment induces me to believe, that powder of algaroth may be uſed advantageouſly for the preparation of an emetic tartar, of more certain and more uniform quality than that which is prepared from glaſs of antimony. *See the reaſons for this opinion, at the word* TARTAR (EMETIC). *See alſo the articles* ANTIMONY, BUTTER *of* ANTIMONY, *and* BEZOAR MINERAL.

DLIV. POWDER. (GUN). Gun-powder is an intimate mixture of 75 parts of purified nitre, of $15\frac{1}{2}$ parts of charcoal, and of $9\frac{1}{2}$ parts of ſulphur. The quickneſs of the kindling of this compoſition, and the violence of the exploſion occaſioned by this ſudden inflammation, is univerſally known. The theory of the detonation of gun-powder is exactly the ſame as that of the detonation of nitre with any other inflammable matter. Therefore we refer to the article DETONATION *of* NITRE for this theory.

The goodneſs and force of gun-powder depend upon two eſſential points, firſt, that all the contained nitre be inflamed; and ſecondly, that this inflammation be made in the ſhorteſt time poſſible, and almoſt in an inſtant.

The proper quantities of ſulphur and of charcoal in the compoſition of nitre procure the inflammation of all the contained nitre; and the quickneſs and force of this inflammation depends upon the intimacy and accuracy of the mixture of the component parts of the powder.

From experience we find that the proportions of the ſeveral ingredients mentioned above are the beſt, that is, that they are ſufficient for the detonation of the whole nitre. A larger quantity of ſulphur and charcoal would leſſen the force of the powder; becauſe altho' theſe ſubſtanees be inflammable, yet the force of their inflammation is nothing in compariſon of detonating nitre. Care muſt be taken that no uninflammable matters be mixed with the gun-powder, and therefore the nitre muſt be very well purified, and freed from the common ſalt mixed with it, which is not inflammable; and alſo from the ſalts with earthy baſes, which are contained in the mother water of nitre, and which have the bad quality of attracting powerfully the moiſture of the air, as this quality renders theſe ſalts capable of ſpoiling powder, in other reſpects good.

The quickneſs of the inflammation of gun-powder depends not only on the purity of the nitre and on the juſt proportion of the ingredients, but alſo on the accurate diſtribution, and the intimate mixture of theſe. The reaſon of this is very evident. As the ſalt-petre cannot be inflamed but by means of immediate contact with ſome inflammable matter, we may eaſily perceive that the finer the particles are of the ſalt-petre, and alſo of the ſulphur and charcoal, and the more intimately theſe three ingredients are mixed, the greater is the number of the points of contact, ſince the ſurface of each of the ingredients is thereby encreaſed; and hence the quicker the detonation muſt be. Accordingly all the operations in the making of gun-powder are to compleat theſe two intentions.

For this purpoſe, nitre of the third boiling, and well purified, is choſen, and alſo very pure ſulphur and good charcoal. The charcoal of light woods is generally employed; but Mr. Beaumé, who has very minutely and accurately examined this matter, affirms from experience, that the charcoals of heavy and hard woods, if they have been well made, are as fit for the purpoſe. Theſe three ingredients are mixed in the proportions above-mentioned, and a very fine diviſion and intimate mixture are made of them, by pounding them together, during twelve hours, in a wooden mortar, and with a wooden peſtle. This mixture muſt be carefully moiſtened from time to time with ſome water, to prevent the matters when too dry from being raiſed and diſſipated by this long trituration, and to prevent the mixture from kindling by the heat occaſioned by the repeated ſtrokes of the peſtle. In large works, a mill is employed for this trituration, in which wooden mortars are diſpoſed in rows, and in each of which a peſtle is moved by the arbor of a wheel turned by water, as in paper mills.

When the trituration is finiſhed, the powder is made. Nothing then remains to be done but to dry it very ſlowly, but compleatly. The powder is in this ſtate compoſed of very fine parts, which are therefore liable to moiſten in the air, to adhere to any thing, to ſoil the fingers and the inſide of fire-arms, into which alſo it does not eaſily ſlide. Theſe inconveniencies are remedied by reducing it to ſmall ſmooth grains, larger for cannons, and ſmaller for muſkets.

The operations by which the powder is reduced into grains are very ſimple, and well imagined. For this purpoſe, it is placed to a certain thickneſs upon ſieves, the holes of which are of a proper ſize; upon this ſtratum of powder a thick piece of wood is placed horizontally, and preſſes upon the ſurface of the powder. All this apparatus is to be agitated horizontally in ſeveral directions. The weight of the piece of wood forces the powder to paſs through the holes of the ſieve, and to form itſelf into molecules of the ſize of the holes. The powder is by this method granulated, but it is not rendered ſmooth. In its rough ſtate it is uſed for artillery; but for ſmall arms it muſt be ſmoothed, and this is effected by an operation as ſimple as the preceding.

For this purpoſe a hollow cylinder or caſk is mounted upon an axis, which is to be turned by a wheel. This caſk is to be filled half full of the powder to be ſmoothed, and it is to be turned ſix hours. The friction occaſioned by this motion of the parts of the powder againſt each other is ſufficient to ſmooth their ſurfaces. The granulation and ſmoothing of the gun-powder cannot be performed without a part of it being reduced to a fine powder, which is to be ſeparated from the reſt by a ſearce, and to be afterwards granulated. Thoſe who require more particular information concerning this manufacture, or other arts and trades, may conſult the *Dictionnaire portatif des arts & des metiers. See the articles* ACID (NITROUS); NITRE; DETONATION *of* NITRE; SULPHUR; COAL. (*d*)

DLV. POWDER *of the* CHARTREUX. *See* KERMES.

DLVI. POWDER (FULMINATING). This powder is a mixture of three parts of nitre, two parts of the dry alkali of tartar, and one part of ſulphur. It is called fulminating, becauſe when it is put upon a gentle fire, in an iron ſpoon, and ſlowly heated, it detonates with aſtoniſhing violence and noiſe as ſoon as it receives the proper heat.

The moſt remarkable circumſtances in this experiment are, that this powder does not require to be forcibly confined, as gun-powder does, to make a great

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(*d*) Mr. Beaumé analyſed a pound of the gun-powder made for the French ordnance. By boiling it in water he extracted 12 ounces of ſalt petre; and by expoſing the reſiduum to a heat juſt ſufficient for the ſlow combuſtion of the ſulphur, he found that it contained two ounces of ſulphur and two ounces of charcoal.

Some perſons, miſled by an experiment of Dr. Hales, which ſhews that burning ſulphur does not generate elaſtic air, but deſtroys the elaſticity of common air, have imagined that the ſulphur was an unneceſſary and even hurtful ingredient of gun-powder. Mr. Beaumé, having made experiments on that ſubject, found that by addition of the ſulphur, the force of gun-powder was nearly doubled.

The uſe of ſulphur, as an ingredient in gun-powder, ſeems to be not to encreaſe the exploſion immediately by its own combuſtion, but to accelerate the combuſtion of the other ingredients, which it does by its property of being much more eaſily inflammable than the charcoal. The charcoal not only concurs with the ſulphur in ſupplying the inflammable matter which cauſes the detonation of the nitre, but alſo conſiderably adds to the exploſive power of the detonating nitre, by the quantity of elaſtic vapor expelled during its combuſtion. Concerning the whole exploſive force of gun-powder, *ſee a Note ſubjoined to the article* DETONATION *of* NITRE.

exploſion, and alſo that heat muſt be applied ſlowly; for the fulmination is leſs ſtrong when the powder is haſtily heated; and although a ſingle gros (c) of this powder is ſufficient, when heat is ſlowly applied, to make a noiſe as conſiderable as that of a cannon, and to produce an exploſion dangerous to byſtanders; yet a much larger quantity may be thrown upon lighted coals without danger, and even without exploſion, becauſe the nitre does then only gently detonate, as it does when it is alkaliſed by charcoal.

The explanation of theſe ſingular effects is deducible from the theory of the detonation of nitre. The exploſion produced by nitre, when inflamed with any combuſtible matter, is ſo much ſtronger as the quantity inflamed at once is larger, ſo that it is the ſtrongeſt poſſible when all its parts kindle at once, and inſtantaneouſly: but this happens in the experiment of fulminating powder. When it is very ſlowly heated, it is firſt liquefied: a kind of liver of ſulphur is formed by the combination of the alkali with the ſulphur which enters into the compoſition of this powder; the phlogiſton of the ſulphur is almoſt entirely diſengaged, and reduced into a vapor which penetrates the maſs on all ſides, and is equally diſtributed betwixt the parts of the nitre, which is then alſo fuſed. Laſtly, when the heat is ſtrong enough to kindle any part of the powder when brought to this ſtate, all the others kindle alſo; both becauſe, by having been ſlowly heated, they have nearly the ſame degree of heat, and alſo becauſe they are all diſpoſed in the moſt advantageous manner to inflammation. They therefore all kindle at the ſame time; and this inſtantaneous exploſion ſtrikes the ſurrounding air with ſuch violence and rapidity, that this fluid has not time to give way to the ſudden percuſſion, and conſequently reſiſts as much the fulmination of this powder, as the chamber of a gun reſiſts the fulmination of gun-powder. Hence fulminating powder does not require to be cloſely confined, as gun-powder does, to make a much more conſiderable noiſe.

This circumſtance alſo is peculiar to fulminating powder, that ſome inſtants before its exploſion, a light blue flame appears upon its ſurface; which is nothing elſe than the phlogiſtic vapors beginning to kindle. No more fire or flame is perceptible during its fulmination: this proceeds from the quickneſs of the exploſion, and the violence of the commotion of the air, by which the flame is extinguiſhed and ſuffocated as ſoon as it is formed, and before it can be perceived. Hence alſo fulminating powder does not generally kindle the combuſtible bodies in contact with it, becauſe the time of its inflammation is too ſhort.

This powder differs in theſe two laſt phenomena from gun-powder, but they are common to it with fulminating gold. If we were certain that *nitrous ſulphur* can ſubſiſt ready formed uninflamed, theſe effects would induce us to believe that it ſubſiſts already combined in fulminating powder and in fulminating gold, ſome time before their exploſion, as Mr. Beaumé thinks. We cannot be certain of this, unleſs we could obtain nitrous ſulphur ſingle and uninflamed, as we can vitriolic ſulphur and phoſphorus. *See* ACID (NITROUS), NITRE, DETONATION *of* NITRE, LIVER *of* SULPHUR, GOLD (FULMINATING), POWDER (GUN), *and* SULPHUR.

(c) A gros is 72 grains.

DLVII. PRECIPITATION, *and* PRECIPITATES. Precipitation is one of the moſt general and important operations of chemiſtry. The term *precipitation*, in its moſt extenſive ſenſe, is applicable to all chemical decompoſitions made by an intermediate ſubſtance, that is, to all operations in which two bodies are diſunited, by employing a third body which has the property of uniting with one of theſe, and thereby of ſeparating the other. Hence we ſee that every precipitation is effected by means of the affinity of a precipitant, much ſtronger than that of the precipitate with the ſubſtance from which it is ſeparated. This is the third caſe of affinity; when three ſubſtances act upon each other. *See* AFFINITY.

This ſurprizing property that certain ſubſtances poſſeſs of ſeparating others ſtrictly united, is the true efficient cauſe of many chemical decompoſitions which could never have been performed by other means. Thus, for inſtance, we ſhould never have known the acid of ſea ſalt, ſedative ſalt, and many other very important ſubſtances in chemiſtry, without the aſſiſtance of ſome acids more powerful than theſe, and capable of ſeparating them from the baſes to which they are united.

Although all theſe decompoſitions eſſentially belong to precipitation, yet uſe has confined this term to thoſe operations only in which the ſubſtance becomes palpable when it is ſeparated, and conſequently falls by its gravity to the lower part of the veſſel in which the operation is made. From this fall of the ſeparated ſubſtance the operation has been called *precipitation*; and the ſubſtance ſeparated, and collected at the bottom of the veſſel, has been called *precipitate*.

We ſhall not ſay any thing here concerning the cauſe of precipitation, becauſe our knowledge is not yet ſufficiently extenſive to enable us to affirm any thing upon the ſubject. An hypotheſis relating to it may be found under the article GRAVITY. In this article we ſhall only mention the principal phenomena of precipitations, and the moſt eſſential properties of ſeveral precipitates.

Precipitation is never occaſioned but in fluid matters; and as bodies may be rendered fluid either by fire or by water, two kinds of precipitations may be diſtinguiſhed, one by the humid way, and the other by the dry way. In the firſt claſs ought to be ranged all decompoſitions of ſalts with earthy or metallic baſes, which ſalts muſt be diſſolved in water when their baſes are to be ſeparated from their acids by proper intermediate ſubſtances. The ſecond claſs includes the ſeparations of metals and of other ſolid and fuſible matters from each other, which are effected by fuſion and mixture with the ſeparating ſubſtances. Theſe two kinds of precipitation do not eſſentially differ: but many real differences diſtinguiſh the ſeparated ſubſtances, or all thoſe to which the general name of precipitate is given. This name has been given very improperly to ſeveral preparations which are not precipitates. Such are the *red precipitate*, *precipitate per ſe*, and ſome others. And amongſt the preparations which may properly be called by this name, becauſe they are ſubſtances ſeparated from other ſubſtances by intermediate bodies, many do eſſentially differ from others, and ought therefore to be diſtinguiſhed by different names.

When a body is decompoſed by means of an intermediate ſubſtance, and a precipitate is formed by this decompoſition, this precipitation can be effected only by the intermediate ſubſtance uniting with one of the component matters of that body; and conſequently a new compound is always formed in theſe operations. Sometimes the ſeparated matter, being no longer ſoluble, becomes ſenſible, and falls as a precipitate, while the new compound remains diſſolved. In other inſtances, the ſeparated ſubſtance remains diſſolved, while the new combination, not being ſoluble, is precipitated. This depends on the nature of the ſubſtances which act one upon another in theſe operations; but we may eaſily perceive that the precipitates of the former kind are ſimple, and thoſe of the latter are compound.

Some modern chemiſts conſider theſe ſimple precipitates only as true precipitates, or which ought to be ſo called. Nevertheleſs, we muſt acknowledge that precipitates of the ſecond kind have all the requiſites to entitle them to the name of precipitate; and no inconvenience attends the giving to them that name, provided they are diſtinguiſhed from the former kind by the denomination of *compound precipitates.*

Earths and metals, when ſeparated from acids by means of alkalis or other metals, are ſimple precipitates, and when ſeparated from acids by other acids, are compound precipitates. For inſtance, calcareous earth united with nitrous and marine acids may be ſeparated from theſe by the vitriolic acid: and if this ſeparation is effected by pouring vitriolic acid into a ſolution of nitre or of marine ſalt with calcareous baſis, the liquors which were before clear will by this addition of vitriolic acid be rendered turbid and milky, and a ſediment or white precipitate will ſoon be formed at the bottom of the liquor. This precipitate is nothing elſe than the calcareous earth which was united with the nitrous or marine acids, and which being ſeparated from theſe acids by the vitriolic acid, unites with this latter and forms a new compound, a ſelenites, the greateſt part of which, not being capable of remaining diſſolved in the liquor, is precipitated. *See* SELENITES.

In the ſame manner, when vitriolic acid or any ſalt containing it is mixed with a ſolution of ſilver, of lead, or of mercury by the nitrous acid, a precipitate is ſoon formed, which is a combination of the metal with the vitriolic acid. *See* VITRIOLS.

The ſame thing may be ſaid of the corneous metals, which are combinations of theſe metals with marine acid, by which they have been ſeparated from nitrous acid. *See* LUNA CORNEA, *and* PLUMBUM CORNEUM.

All the precipitates above-mentioned are really new combinations of the precipitated ſubſtance with the precipitating acid; and which only ſeparate from the liquor, and appear as precipitates, becauſe they are are not very ſoluble, and the liquor contains too little water to keep them ſuſpended. This may be proved by adding a ſufficient quantity of water, by which this kind of precipitates will be entirely diſſolved. Nevertheleſs this circumſtance does not prevent their being precipitates, when they are actually made by precipitation. For amongſt the precipitates conſidered as ſimple, and to which many chemiſts would confine the name of precipitate, perhaps there is not one really ſimple. Modern chemiſts have obſerved, that all precipitates in general draw along with them a greater or leſs quantity of ſome other ſubſtances during the precipitation. They either retain a part of the ſubſtance with which they were united before precipitation, or a part of the precipitant, and frequently even a certain quantity of each of theſe matters. This depends on the nature of the bodies which act upon one another, on their proportions, and on concomitant circumſtances. If any precipitates can be conſidered as pure and ſimple, certainly a metal precipitated from an acid by another metal may, as, for inſtance, ſilver and mercury ſeparated from the nitrous acid by copper, or copper ſeparated from acids by iron; becauſe the precipitated metal reſumes its natural color, luſtre, and metallic properties. Nevertheleſs, when we ſubject theſe metallic precipitates to accurate trials, we diſcover that they are allayed with a ſmall quantity of the precipitating metal. In general, precipitates and the different circumſtances of precipitation have been hitherto but ſuperficially examined. It is a ſubject no leſs important than new, which deſerves attention, and is replete with many diſcoveries.

After theſe explanations which we thought neceſſary concerning precipitation and precipitates in general, we proceed to treat of the principal chemical preparations called precipitates; becauſe theſe which are not called precipitates, although they really be ſo, are treated of under other articles.

MERCURIAL PRECIPITATES.

DLVIII. PRECIPITATE (WHITE). This is mercury ſeparated from nitrous acid by marine acid, with which it then unites. White precipitate is made by pouring a ſolution of common ſalt in diſtilled water into a ſolution of mercury in nitrous acid, till no more precipitate falls. When the ſediment is collected at bottom, the ſupernatant liquor is to be decanted, and the precipitate is to be waſhed ſeveral times with diſtilled water, and then dried.

This precipitate of mercury is one of thoſe called compound. It is a combination of mercury with the acid of common ſalt; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only ſeparated from the nitrous acid by means of the combination it forms with the marine acid. In this precipitation, then, the phenomena are ſimilar to thoſe which happen in the formation of luna cornea and plumbum corneum. 1. White precipitate may be made by pure marine acid. 2. When it is made by common ſalt, or other ſalt containing marine acid, two decompoſitions happen, and two new combinations are formed. The nitrous acid which was originally united with the mercury combines with the ſubſtance that was united with the marine acid, and forms a new nitrous ſalt, which remains diſſolved in the liquor. When common ſalt is employed, cubic nitre is formed. If marine ſalt with an earthy baſis is uſed, the liquor after the precipitation, contains a nitre with earthy baſis. Upon this ſubject *ſee the article* AFFINITY. 3. All the mercury, although entirely ſeparated from nitrous acid and united with marine acid, is not precipitated in the preſent occaſion, becauſe it is reduced to a ſaline compound eſſentially ſoluble in water; and conſequently the liquor contains as much of it as it can diſſolve, and another part of it is diſſolved by the water employed to waſh it. Similar events happen alſo in the precipitation of ſilver and of lead by marine acid. Accordingly, if an alkali be added to clear the liquor decanted from theſe precipitates, or even to the water employed to waſh them, another precipitate will be formed; but this latter is of a different nature, and is ſimple in compariſon of the former, ſince it does not contain any acid combined directly with the metallic ſubſtances, or, at leaſt, much leſs of the acid.

Lemeri gives another proceſs for making a white precipitate, which conſiſts in diſſolving four ounces of ſal ammoniac in a pound of water; to which is to be added an equal quantity of corroſive ſublimate; all which could not be entirely diſſolved alone in that quantity of water, but may by means of the ſal ammoniac. *See* SUBLIMATE (CORROSIVE), *and* TINCTURE *of* MERCURY. Into this ſolution liquid fixed alkali is to be added, till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by ſeveral chemiſts; but it ought not to be confounded with the white precipitate formed by adding marine acid or common ſalt to a ſolution of mercury in nitrous acid; for they are evidently very different.

We may remark, that the color of this precipitate of Lemeri is influenced by the ſal ammoniac; for although this precipitate be very white, the precipitate formed by adding fixed alkali to a ſolution of corroſive ſublimate in water is brick-colored. The whiteneſs of the former precipitate then proceeds from the great quantity of marine acid, and even of the volatile alkali of the ſal ammoniac, which affect this precipitation. This proves, that precipitates reputed ſimple are not ſo; and that they draw along with them part of the ſubſtances to which they were united, and of the precipitating ſubſtances. Great differences may be obſerved in this reſpect amongſt precipitates in general, according to the quantity and proportions of ſubſtances which concur to the precipitation.

DLIX. PRECIPITATE (YELLOW). As chemiſts have given many different forms to mercury, to adapt it to medicinal uſes and to chemical proceſſes; ſo they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations which in fact are not precipitates. Theſe are chiefly denominated from their colors, without adding any epithet to ſhew that they are mercurial. Thus *white precipitate*, *yellow precipitate*, *red precipitate*, &c. are preparations of mercury. Yellow precipitate is mercury diſſolved by vitriolic acid, from which it is afterwards ſeparated by addition of water alone; it is then in form of a yellow powder: but as this precipitate is better known by the name of TURBITH MINERAL, we ſhall treat of it under that article.

DLX. PRECIPITATES (BLACK *and* ROSE-COLORED). Lemeri, who mentions many precipitates of mercury, of different colors, ſays, that if a ſolution of mercury in ſpirit of nitre be precipitated by urine, inſtead of a ſolution of common ſalt, a roſe-colored precipitate of mercury will be formed; and that if afterwards ſome fixed or volatile alkali be added to the liquor from which the roſe-colored precipitate has been formed, another precipitate which is black will be obtained.

Much common ſalt being contained in urine occcaſions the roſe colored precipitate, which is eſſentially the ſame as the white precipitate obtained by pure ſea-ſalt or marine acid. The redneſs of its color probably proceeds from ſome reddiſh earthy or ſaline-earthy matter contained in urine, which it draws along with it.

The blackneſs of the precipitate obtained afterwards by adding alkali proceeds from the oily and phlogiſtic parts of the urine, which are added ſuperabundantly to the mercury, and which always blacken white metals, as ſilver, lead, biſmuth, theſe metals being ſuſceptible of receiving inflammable matter ſuperabundantly, when they are expoſed to vapors of ſulphur, of liver of ſulphur, or when they are precipitated by this latter ſubſtance. *See* LIVER *of* SULPHUR.

DLXI. **PRECIPITATE PER SE.** This preparation of mercury is very improperly called a precipitate; becauſe it is not ſeparated from one ſubſtance by means of another ſubſtance, as all true precipitates are, but is only mercury reduced to a red powder by a kind of calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glaſs matraſs, the neck of which is very long, and the opening of a capillary ſize. This matraſs, the belly of which ought not to be entirely full of mercury, is to be placed in a ſand-bath, and heated till the bottom of the veſſel containing the ſand be red-hot. This heat is to be continued during two or three months. The mercury gradually loſes its luſtre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the ſurface of the mercury, or adheres to the ſides of the veſſel. The operation may be ſhortened by uſing a greater number of matraſſes, all which may be placed in the ſame bath. When enough of this red powder is obtained, it is to be collected and ſeparated from the remaining fluid mercury. This is called *precipitate per ſe*, or *by itſelf*, or *red precipitated mercury without addition*.

This preparation of mercury we have received from the alchemiſts, who ſpared no pains nor labor to change mercury and to fix it. They received great hopes from the change of color, the want of fluidity, and the diminution of volatility which the mercury ſuffers by this operation. Although the mercury is much diſguiſed by theſe changes, yet it is not eſſentially altered, becauſe it may be reduced to fluid mercury by heat without addition. We cannot preciſely explain the phenomena of this operation. Different opinions are formed concerning them. Mr. Baron conjectures, that they are cauſed by the union which mercury contracts by means of its being much divided with the ſaline particles contained in air. We ſee indeed from turbith mineral and red precipitate, that mercury is diſpoſed to take the form and qualities of the precipitate per ſe, by an union with a ſmall quantity of ſaline ſubſtance. Mr. Beaumé thinks, on the contrary, that the mercury is truly calcined, that it loſes part of its phlogiſton; and that, when it is expoſed to heat, it is again reduced to its metallic ſtate by the addition of the inflammable principle which paſſes through the containing veſſels, and again combines with it. This opinion is not improbable; but more experiments and reſearches are wanting to decide concerning it. I ſhould be, nevertheleſs, ſufficiently diſpoſed to believe, that a part of the inflammable principle contained in fluid mercury is ſuperabundant to it, ſlightly adherent, and may be eaſily loſt and recovered.

DLXII. **PRECIPITATE (RED).** If a ſolution of mercury in nitrous acid be reduced to dryneſs by evaporation, and the mercurial nitre thence formed be put into an open matraſs ſet in a ſand-bath, with a fire gradually encreaſing, the nitrous acid will diſengage itſelf from the mercury, and evaporate in a red vapor. While the acid evaporates, the ſaline mercurial maſs loſes its original whiteneſs, becomes yellow, then orange, and laſtly red.

This red matter, when ſeparated from the matraſs, (which muſt be broken for that purpoſe) and pulveriſed in a glaſs mortar, is the *red precipitate*, as it is improperly called; it not being a precipitate, but a mercurial nitre from which the greateſt part of the acid is expelled by the fire, without the application of any intermediate ſubſtance. The red color of this preparation is cauſed by the great diviſion of the molecules; for, from the example of the precipitate per ſe, and of ſeveral true mercurial precipitates, which alſo are red, we learn that this is the color aſſumed by mercury when it is not fluid, when its parts are much divided, and when it has not a ſuperabundant quantity of phlogiſton.

Notwithſtanding the calcination which mercurial nitre ſuſtains in this operation, all its nitrous acid is not expelled. The mercury ſtill retains a quantity of acid equal to the ninth part of its weight, as Mr. Lemeri obſerves. This preparation is therefore corroſive, and only uſed externally. Several authors propoſe to render it milder by burning ſpirit of wine two or three times over it. It is then called *arcanum corallinum*, and has been given by ſome phyſicians internally. If it be indeed rendered milder by this inflammation of ſpirit of wine, the effect muſt be produced by a partial reduction of the mercury, occaſioned by ſome phlogiſton which it receives from the ſpirit of wine; but the internal uſe of this precipitate is aboliſhed, becauſe the effects of other preparations are more uniform and certain.

Red precipitate is much leſs volatile than crude mercury. Nevertheleſs, by a ſtrong fire in cloſe veſſels it may be ſublimed entirely, and the ſublimate has the ſame color and other qualities as the precipitate. As nitrous acid is a very powerful agent to deprive bodies in general, and particularly metallic ſubſtances, of part of their phlogiſton; and as red precipitate has all the appearance of a mercury partly deprived of its inflammable principle; I have endeavored to calcine it further by leaving it expoſed a long time to fire, and by diſſolving it many times in freſh nitrous acid. For this purpoſe I digeſted during four days ſome red precipitate with a ſtrong heat, which I then diſſolved in more nitrous acid, afterwards reſtored it to the ſtate of red precipitate, and then calcined it again during four days. Eight times I repeated theſe calcinations and ſolutions: but when I examined my mercury, it appeared to be juſt the ſame as it was after the firſt ſolution and calcination. This determined me to relinquiſh the experiment. It proves, that if the nitrous acid does deprive the mercury of any of its phlogiſton, the quantity of this principle is very ſmall which it thus detaches, and is only that which is but little adherent and ſuperabundant. It alſo proves, that nitrous acid takes as much phlogiſton from the mercury the firſt time as it can; and that therefore any attempts to dephlogiſticate it perfectly would be unſucceſsful by this, or probably by any other method, ſince this ſeems to be the moſt effectual.

Lemeri obſerves, that many authors have believed that the color of red precipitate might be much heightened by thrice cohobating and diſtilling the white maſs above-mentioned with ſpirit of nitre; and he affirms, that this effect is not produced by theſe operations. This experiment is ſimilar to that I have mentioned, but is leſs capable of changing the mercury, becauſe it is not calcined after each diſtillation. I have alſo remarked, that red precipitate is eaſily ſoluble, and produces heat, but no effervescence, with new nitrous acid. Lemeri obſerved the ſame phenomenon with vitriolic acid.

DLXIII. PRECIPITATE (GREEN); *and* **PRECIPITATE (BLACK),** *or* **VIOLET-COLORED MERCURY.** Some authors, particularly Lemeri, give proceſſes for other preparations of mercury, which have been employed as remedies, and which are improperly called *precipitates.* Such is green precipitate, which is a mixture of four parts of mercury and one part of copper, diſſolved ſeparately in the nitrous acid, and treated as in the proceſs for making red precipitate; afterwards, partly diſſolved a ſecond time by being digeſted with vinegar; and, laſtly, reduced by evaporation to a dry conſiſtence. Such alſo is the preparation called by Lemeri *violet mercury*, or *black mercurial panacea*, or *black precipitate*, which is an artificial cinnabar overcharged with ſulphur, mixed with ſal ammoniac, and prepared by a very long and laborious proceſs: but as theſe preparations have been made only for the uſe of medicine, and have fallen into diſrepute, we ſhall not ſay any more of them, excepting that they are ſingular mixtures, accompanied with many unforeſeen appearances, which could not be explained without further examination and particular diſſertations. *See the article* MERCURY *for the medicinal virtues of all the mercurial preparations called precipitates.*

DLXIV. PRECIPITATE *of* **GOLD** *by* **TIN,** *or* **PURPLE POWDER** *of* **CASSIUS.** This precipitate of gold may be made by ſeveral methods: but which of theſe is the beſt, has not yet been decided. The cauſe of this uncertainty is, that the preparation requires delicate management, and is uncertain in its reſult, the beauty of the color ſeeming to depend on ſome ſmall circumſtances not yet diſcovered; for we find that the color of the powder obtained frequently varies, notwithſtanding the proceſſes ſeem to have been the ſame. I have tried ſeveral methods. The following is what has beſt ſucceeded with me, and is nearly the ſame as that deſcribed by Mr Gellert in his Metallurgic Chemiſtry.

Make an aqua regia with two parts of ſpirit of nitre and one part of ſpirit of ſalt; dilute this acid with an equal quantity of diſtilled water; add to it a ſmall piece of Malacca tin, and let it be diſſolved without heat. If the weather be cold, the time employed in this ſolution will be long; but this is rather an advantage than an injury. When this piece of tin is entirely diſſolved, add another, and let it be diſſolved in the ſame manner; continue to add more pieces of tin, one at a time, till the liquor has acquired a yellow color, and almoſt ceaſes to act upon the tin; then decant the liquor from the remaining piece of metal.

Alſo diſſolve gold of 24 karats in an aqua regia compoſed of three parts of ſpirit of nitre, and one part of ſpirit of ſalt. This ſolution may be accelerated by the heat of a ſand-bath.

Dilute the ſolution of tin in a hundred times its quantity of diſtilled water. Try your ſolutions in the following manner: Take a ſmall quantity of the diluted ſolution of tin; divide it into two parts; to one of which add a known quantity of diſtilled water: to each of theſe portions of the ſolution of tin add a drop of the ſolution of gold, by which they will acquire a red purple color: obſerve which of the colors of the two ſolutions is the fineſt, and keep to that degree of dilution for the reſt of the ſolution of tin: to the ſolution of tin thus diluted add ſuch a quantity of the ſolution of gold, that there ſhall be in the mixture two parts of the former metal to one of the latter: ſtir well the mixture (which ought to be made in a large glaſs veſſel) with a glaſs rod. The whole will acquire the color of red wine, and a ſediment will gradually be depoſited of the ſame color, while the liquor will become clear. Then pour into this clear liquor ſome drops of the ſolution of tin, and obſerve if any more gold is precipitated: when the liquor is very clear, decant it gently from the ſediment, which is to be well waſhed with pure diſtilled water. This is precipitate of gold, or the purple powder diſcovered by Caſſius. It is a valuable preparation, becauſe it is the only one known capable of giving a red purple or crimſon color to glaſs, enamel, and porcelain. When it is to be uſed, it muſt be well mixed, and ground with a fuſible glaſs, as Venice glaſs; and this mixture is to be expoſed to the degree of heat neceſſary for melting the glaſs. If a colored glaſs or artificial ruby be required to be made, ſo large a quantity of glaſs is to be added to the mixture that the gold ſhall not deſtroy its tranſparency: but for enamel painting, a ſmaller quantity of glaſs is required, that the color may be intenſe. The particular proportions cannot be aſcertained, becauſe the intenſity of the color given by the gold is very variable.

We have already remarked, that this preparation is ſubject to varieties; and that by the ſame proceſs it is ſometimes more and ſometimes leſs beautiful. Sometimes we can obtain only a precipitate of a black violet color; at other times we can obtain ſcarcely any color, without being able to diſcover the reaſon of theſe differences. We know, however, many eſſential circumſtances concerning the ſucceſs of the operation. We are certain, that little or no purple precipitate will be formed when the tin has been quickly diſſolved, and with heat and effervеſcence. To underſtand the reaſon of this, we muſt recollect the following principles.

Firſt, the gold is really precipitated in this experiment; for the purple powder may be reduced to gold. Beſides, we know that this metal, when much divided and united with ſome ſaline parts, or perhaps even with a ſuperabundant quantity of phlogiſton, has always a reddiſh-purple or violet color.

Secondly, the gold is here precipitated only by means of the tin; becauſe this latter metal has a ſtronger affinity than the former with the acids of aqua regia; and although it already is united with the ſame acids, it yet ſeizes thoſe ſuperabundantly that keep the gold diſſolved, which it therefore precipitates. This propoſition is proved by obſerving, that nothing elſe is added to the ſolution of gold in the preparation of the purple powder, than tin, aqua regia, and water; but as no quantity of aqua regia and water can occaſion this precipitate, the tin therefore is the ſubſtance which does occaſion it. Beſides, gold may be formed into a purple precipitate by adding a piece of tin to a ſolution of gold in aqua regia. If a queſtion be aſked, Why, when we employ a ſolution of tin, that is, tin united with ſo much acid that it remains diſſolved in much water, this tin ſhould nevertheleſs ſeize upon the acids which keep the gold diſſolved? the reply is, That tin is capable of charging itſelf with a

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larger quantity of acid than is neceſſary to diſſolve it; and alſo, that when its ſolution is diluted in a large quantity of water, more acid is required to keep the metal diſſolved: for when a great deal of water is added to a clear ſolution of tin, the liquor will become turbid, and the tin will be precipitated. We cannot then be ſurprized that the tin, which in this dilute ſolution is on the point of precipitating before the ſolution of gold is mixed with it, and which then has ſcarcely a ſufficient quantity of acid to keep it diſſolved, ſhould, when that mixture is made, ſeize the acids of the ſolution of gold.

Thirdly, we know that metals are capable of being diſſolved in acids by means of their phlogiſton. We know alſo that acids, and particularly the nitrous, take from the imperfect metals a part of their phlogiſton during the ſolution of theſe metals, and that this loſs of phlogiſton ſuſtained by metals is ſo much more conſiderable as the ſolution is made with more activity, quickneſs, and heat. Tin is more ſubject to loſe its phlogiſton than any other metal; hence it cannot continue ſuſpended in the nitrous acid, which takes ſo much of its phlogiſton from it, that it is ſoon reduced to a white calx: although the marine acid, a large quantity of which is in the ſolution of tin employed for the preparation of the purple powder of Caſſius, conſiderably moderates the action of the nitrous acid, and prevents ſo compleat a dephlogiſtication as is occaſioned by pure nitrous acid; nevertheleſs, when this ſolution is performed with too much activity, the tin is too much calcined, part of it is often precipitated in form of a white calx, and the remaining part which is diſſolved contains ſo little phlogiſton, that the acids of the ſolution of gold cannot act properly upon it: hence ſuch a ſolution of tin is unfit for the preparation of the purple precipitate of Caſſius, and it frequently is incapable of forming it: hence we ſee the reaſon why the ſucceſs of the operation depends ſo much on the ſlowneſs with which the tin is diſſolved.

The ſolution of tin muſt be diluted in much water, elſe a fine color will not be produced. The reaſon of this is, that the tin is ſo much more capable of precipitating the gold, as by the dilution of the acids with which it is united, it is more diſpoſed to fall down ſpontaneouſly. Accordingly, a certain quantity of tin is always precipitated along with the gold, which appears in form of a white calx.

The ſolution of tin in aqua regia is not the only ſubſtance with which a purple powder of gold may be made. We have already ſeen, that a ſmall piece of tin put in a dilute ſolution of gold forms a purple precipitate Orſchal mentions this and ſeveral other very curious experiments on the ſame matter, in his little Treatiſe called *Sol ſine Veſte*. For inſtance, we there find that the ſmoking liquor of Libavius makes alſo a purple precipitate. I have found that tin diſſolved in marine acid likewiſe makes it. The ſame chemiſt further ſays, that a ſolution of mercury in ſpirit of nitre mixed with a ſolution of gold produces a more beautiful precipitate than tin; that fulminating gold, that gold itſelf when much divided, like the powder ſcraped off a piece of gold by pounce-ſtone, being mixed and melted with vitreous matters, make a red glaſs. Theſe facts prove, that this color is natural to gold, whenever it is very much divided.

This purple powder appears to have been a ſecret and a novelty in the time of Orſchal; as he ſays that he learnt it from Caſſius himſelf. Several cotemporary chemiſts believed, that the gold was decompoſed in this operation, and vitrified in the red glaſs which received its color from it: but Orſchal, leſs diſpoſed to the marvellous, becauſe he was more intelligent, remarks, that the gold is not decompoſed, and only is leſs eaſily reducible than when under another form; which is a true explanation. *See* TIN *and* GOLD. (*f*)

DLXV. PRINCIPLES. This name is given to ſubſtances obtained from compound bodies, when their analyſis or chemical decompoſition is made.

Philoſophers and chemiſts have long ago diſcovered, that almoſt all natural bodies are capable of being reduced to a greater or leſs number of other bodies leſs compounded, ſimilar to each other, and almoſt the ſame, of whatever nature the body was from which they were ſeparated. This important obſervation has induced a belief, that the innumerable productions of nature were only the reſults of the combination of a few more ſimple ſubſtances, the different proportions and arrangements of which formed the diverſity of all compound bodies. Theſe laſt bodies retain the name of *compounds*; and the more ſimple ſubſtances, from the union of which theſe compounds reſult, are called *principles*: but as the number and nature of the principles of bodies can only be diſcovered and aſcertained by many laborious chemical experiments, and as in theſe latter times only, chemiſtry has been properly cultivated as a part of natural philoſophy, ancient philoſophers could only give vague conjectures concerning the number and nature of the principles of bodies. Accord-

(*f*) Long cylindrical pieces of glaſs, called *Jews glaſs*, are commonly ſold, and much uſed by manufacturers of glaſs-toys. This glaſs, though perfectly colorleſs, yet when it is expoſed to the heat and flame of a lamp, acquires a beautiful ruby color, exactly ſimilar to that of pure glaſs melted with powder of Caſſius. As no other known ſubſtance but gold gives that color to glaſs, we may preſume that this glaſs contains ſome of that metal; in which caſe, the gold appears to be vitrified, and more changed than in any other known preparation of it. Kunkel ſays, that having occaſion frequently to make this ruby glaſs, he had ſometimes obſerved the glaſs, when taken out of the crucible, inſtead of being colored as uſual, to appear colorleſs as cryſtal, and to acquire a ruby color by expoſure to the flame of a lamp.

Dr. Lewis obſerves, that though a purple or a ruby color may eaſily, by the methods publiſhed, be applied upon glaſs or enamels, and introduced into the maſs by fuſion, the way of equally diffuſing ſuch a color thro' a quantity of fluid glaſs is ſtill a ſecret. That author ſays, that he has made ſeveral trials of this kind, in one of which the glaſs was uniformly tinged of a ruby color; and in the others various colors, as yellow, red, and brown, appeared, and were unequally diffuſed: but he had not diſcovered the circumſtances upon which theſe differences depend. Orſchal, in his Treatiſe *Sol ſine Veſte*, gives a proceſs by which he obtained a fine ruby glaſs. He directs, that the powder of Caſſius ſhould be ground with ſix times its quantity of Venice glaſs finely powdered; and that this mixture ſhould be well mingled with a fritt conſiſting of equal parts of borax, nitre, and fixed alkaline ſalt, and four times as much calcined flint as of any of the ſalts: but he does not mention the proportion of the powder of Caſſius to the fritt, nor in what manner the fuſion is to be performed.

Kunkel ſays, that one part of the powder of Caſſius is ſufficient to give a ruby color to twelve hundred and eighty parts of glaſs.

Dr. Franklin obſerves, that gold-leaf placed betwixt two plates of glaſs being expoſed to an electrical ſhock, ſtained the contiguous glaſs with red ſpots, which were ſunk into the body of the glaſs.

ingly, in each ſchool of philoſophy different opinions prevailed concerning theſe principles, ſome of them admitting one only, and others more: ſome aſſerting that water was the principle of all things; ſome contending for earth, and others for fire. We do not intend to diſcuſs all theſe opinions; but ſhall only obſerve, that almoſt all the ancient philoſophers have been miſtaken from a want of a ſufficient number of chemical experiments and obſervations.

The chemiſts of the middle ages, that is to ſay, about the time of Paracelſus, had very confuſed notions concerning this matter. They admitted five principles of bodies, which they called *mercury* or *ſpirit*, *phlegm* or *water*, *ſulphur* or *oil*, *ſalt*, and *earth*. By *mercury* they probably meant whatever is volatile, and which in the analyſis of bodies is capable of affecting the taſte and ſmell. This conjecture is confirmed by the name *ſpirit*, which they alſo gave to the ſame principle. Their *phlegm* comprehends all the watery uninflammable products obtained in the analyſis of bodies. By *ſulphur* they meant not only ſulphureous matters and common ſulphur, but alſo any oils, and all the inflammable matters obtained in the decompoſition of bodies. All ſaline matters obtained in theſe analyſes were comprehended under the general name *ſalt*. Laſtly, they applied the word *earth* to the fixed matters which remain after the analyſis of bodies. We ſhall afterwards ſee that ſome of theſe principles, which are called the principles of Paracelſus, are ſimpler than others; hence obſcurity and confuſion have been introduced into the opinions formed concerning principles in general.

Beccher, perceiving this inconveniency in the principles of Paracelſus, attempted to reduce their number, and to give more preciſe notions of them. He eſtabliſhed only two general principles of all bodies, namely, water and earth: but as he could not explain the properties of all compounds from theſe two principles, he admitted three kinds of earths, which he conſidered as equally ſimple and elementary. The firſt he called *vitrifiable earth*, which, according to him, is the principle of the fixity, of the ſolidity, and of the hardneſs of bodies. He called his ſecond earth *inflammable earth*, which he ſuppoſes to be the principle of inflammability of all inflammable bodies. Laſtly, the third earth of Beccher is called *mercurial earth*. He conſidered this earth as forming with the two others metallic ſubſtances, and he alſo admitted it as a principle in the compoſition of other bodies, particularly of the marine acid. This chemiſt gave the name *earth* to theſe three laſt mentioned principles, becauſe he conſidered them as being of a dry nature, and as differing eſſentially from water, which he conſidered as a principle eſſentially humid.

The theory of Beccher concerning principles is very profound, and may be conſidered as the ſource of the moſt important diſcoveries of modern chemiſtry: but we muſt confeſs, that had not the illuſtrious Stahl commented upon this theory, illuſtrated and extended it, we might have received no benefit from it.

This excellent chemiſt eaſily ſhewed, that water and vitrifiable earth enter as elements into the compoſition of many bodies; for theſe two principles are ſenſible, and all the experiments of chemiſts ſhew their exiſtence in moſt compounds: but the other two principles of Beccher, namely, his mercurial earth and his inflammable earth, have not, even yet, been expoſed to our ſenſes, ſingle and pure; and therefore all the ſagacity and genius of Stahl were required to demonſtrate the exiſtence and properties of this inflammable earth, which we now call *phlogiſton*, or *inflammable principle*, and which is nothing elſe than the very ſubſtance of fire when rendered a principle of bodies. *See* PHLOGISTON.

The exiſtence of the mercurial earth is not ſatisfactorily demonſtrated either in the works of Beccher or of Stahl. We have nothing but inferences and preſumptive proofs of its exiſtence. *See upon this ſubject* METALS *and* METALLISATION.

That earth, water, and fire enter into the compoſition of bodies as principles, may be conſidered now as demonſtrated by Beccher and Stahl. The experiments of many philoſophers and chemiſts, particularly Boyle and Hales, have ſhewn that air alſo enters into the compoſition of many bodies as a principle, and even in very large quantities. Thus if we add this fourth principle to the three others above-mentioned, we ſhall find to our ſurprize, that we now admit as principles of all compounds the four elements, fire, air, water, earth, which Ariſtotle taught were ſuch, long before the knowledge of chemiſtry was ſufficient to eſtabliſh this truth.

In whatever manner bodies are decompoſed, we always obtain theſe ſubſtances. They are the utmoſt limits of chemical analyſis. As we cannot by any means decompoſe theſe further, we conſider them as ſimple ſubſtances, (although perhaps they may not be ſo) and are therefore called *primary principles* or *elements*. *See* ELEMENTS, AIR, EARTH, FIRE, WATER, PHLOGISTON.

When we decompoſe moſt bodies, we cannot nearly reduce them to their elements or primary principles by a firſt analyſis, eſpecially when they are much compounded. We obtain from them ſubſtances more ſimple only, but ſtill compounded of other principles, for a reduction to which another analyſis is requiſite. As theſe ſubſtances, although compounded of a certain number of principles, do themſelves the office of principles in the compoſition of bodies leſs ſimple than themſelves, they have been called *principiate principles*. The principiate principles have ſo much better title to this name, as they ſubſiſt in their ſtate after they have been ſeparated from a body, characteriſed by peculiar properties, unalterable but by a new analyſis, and capable of reproducing by their union a compound entirely like that from which they were originally ſeparated. Moſt chemical agents, as acids and alkalis, are of this kind.

In the analyſis of very compound bodies, principiate principles of different degrees of ſimplicity, or rather ſuch as are capable of being reduced to others more and more ſimple, may be thus obtained ſucceſſively, by firſt, ſecond, and third analyſes; hence ſeveral kinds of principiate principles of different degrees of ſimplicity, and which conſequently are, by a true gradation, principles of one another, have been diſtinguiſhed. Modern chemiſts diſtinguiſh them by names which mark their order of compoſition. Thus ſubſtances which cannot be further decompoſed, and which are conſidered as ſimple, are called *primary principles*. *Secondary principles* are thoſe which reſult immediately from the union of primary principles. *Principles of the third order* are thoſe which are compoſed of ſecondary principles; and ſo on.

We may alſo with propriety diſtinguiſh the principles of bodies by the names of *proximate principles* and *remote principles*, by applying the former name to the principiate principles obtained directly from a body by a firſt analyſis, and by applying the latter name to the principles obtained by a further decompoſition of theſe proximate principles.

Theſe diſtinctions will be rendered more intelligible by an example; for the ſubject of which let us chuſe a neutral ſalt, ſuch as nitre. We have demonſtrated that this ſalt is a compound of the acid, called *nitrous*, and of the fixed vegetable alkali, combined and ſaturated together. By a firſt analyſis then of nitre we ſhall obtain this acid and this alkali, which are therefore the proximate principles of nitre. But neither nitrous acid nor fixed alkali are ſimple ſubſtances. By a further analyſis of each of theſe, they may be decompoſed into water, earth, fire, or inflammable principle. This acid and this alkali muſt then be conſidered as *principiate principles*. But as the ſubſtances obtained from them are unalterable, and cannot be further decompoſed, they muſt be conſidered as *primary principles*; the acid and the alkali of the nitre are then immediately compoſed of primary principles, and they themſelves are conſequently principiate principles, or ſecondary principles, or *principles of the ſecond order*. In this example the water, earth, and fire, are the remote principles of the nitre.

Altho' theſe ſeveral denominations and diſtinctions of principles more or leſs ſimple be juſt and uſeful for the illuſtration of many important points in the theory of chemiſtry, this ſcience is not however ſufficiently advanced to enable us to determine the number and kinds of principiate principles of different orders, and eſpecially of the higher orders. We know but a few, which, we have ſtrong reaſons to believe, belong to the ſecond order; ſuch, for example, are ſaline ſubſtances, and the more ſimple acids and alkalis; but we are not entirely certain of this, becauſe we have not been able to produce any of theſe ſubſtances from the union of the primary principles, in ſuch a manner, that no doubt can be admitted. *See the articles* COMBINATION, ANALYSIS, DECOMPOSITION.

DLXVI. PUMICE-STONE. (g)

DLXVII. PURIFICATION. By purification is meant any chemical operation by which ſubſtances required to be obtained pure and ſingle are ſeparated from other heterogeneous matters with which they happen to be mixed.

As the ſeveral chemical agents and other matters are generally more or leſs confounded, and even combined with ſubſtances of different natures, and as we require in many accurate experiments that they ſhould be very pure, we muſt therefore apply the proper methods to give them the neceſſary degree of purity.

But theſe methods differ very much according to the nature of the ſubſtance to be purified. They muſt be appropriated to their peculiar natures, and alſo to the nature of the ſubſtances to be ſeparated. For the ſeveral purifications, we are obliged to employ almoſt all the operations of chemiſtry. Hence many operations are only true purifications, altho' they are not ſo called. For inſtance, all the ſecond diſtillations and ſublimations called *rectifications*, are nothing elſe than purifications. They are employed for the purification of volatile ſubſtances from others that are fixed, or leſs volatile. In this claſs may be ranged the rectifications of oils, of volatile ſpirits and ſalts, of ardent ſpirits, and even of mineral acids; and the ſublimations of ſulphur, of arſenic, of cinnabar, of ſalt of amber, of flowers of benjamin, and of ſal ammoniac. *See* RECTIFICATION *and* SUBLIMATION. Alſo the repeated ſolutions, filtrations, evaporations, and cryſtallizations of neutral ſalts are only means of purifying them. *See* CRYSTALLIZATION, *and* SALT (NEUTRAL). Several calcinations, and particularly thoſe of fixed alkalis, are intended merely to purify them, by depriving them of a greaſy matter or ſuperabundant inflammable principle. *See* CALCINATION, *and* ALKALI (FIXED). Many ſolutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their allay. Laſtly, the repeated fuſions of metallic ſubſtances, the ſmelting of ores, cupellations, and refining, are true purifications of metallic matters. Amongſt all theſe operations, but a very few are called *purifications*: ſuch as the purification of ſilver by nitre, of gold by antimony; of both which we ſhall now treat.

(g) PUMICE-STONE is a light, porous, ſpongy ſtone, reſembling the ſcoria of furnaces. Its colors are white, yellowiſh, brown, or black. It is found near volcanos, and is believed to be a ſubſtance reduced to a burnt or ſemi-vitrified ſtate by ſubterranean fires. Wallerius conjectures that it is the aſhes of foſſil coals thus changed by fire. Pumice-ſtone is fuſible by intenſe heat.

DLXVIII. PURIFICATION *of* SILVER *by* NITRE. The ſilver to be purified by nitre is to be firſt granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potaſh, and a little common glaſs, all in powder. This mixture is to be put into a good crucible, two-thirds of which only muſt be full. This crucible is to be covered with a ſmaller crucible inverted, and luted to the former, and in the bottom of which a ſmall hole has been made. The crucibles thus diſpoſed are to be placed in a furnace, capable of drawing air ſufficiently to make the fire intenſe enough only to melt the ſilver. Then charcoal is to be put into the furnace to ſuch a height, that only the top of the inverted crucible ſhall be uncovered. The coal is then to be kindled, and the veſſels to be made moderately red: a hot coal ought to be put upon the ſmall hole in the bottom of the inverted crucible. If a ſhining light be obſerved round this coal, and a ſlight hiſſing noiſe be at the ſame time heard, we may know that the operation proceeds well. The fire muſt be ſuſtained at the ſame degree, till theſe appearances ceaſe; when it muſt be encreaſed ſo that the ſilver be well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the ſilver will be found at the bottom covered with a green alkaline ſcoria. If the metal be not ſufficiently pure and ductile, the operation muſt be again repeated.

This operation is founded on a property which nitre has of effectually calcining all imperfect metals, by burning their phlogiſton; and alſo upon a property of calcined metals, by which they cannot be united with others in their metallic ſtate. This being eſtabliſhed, when ſilver allayed with copper or other imperfect metals is to be treated with nitre, this ſalt quickly calcines theſe imperfect metals by detonating with their inflammable principle; and they are no ſooner calcined, than they are rendered incapable of remaining united with the ſilver. Theſe metallic calxes being alſo ſpecifically lighter, riſe above the ſilver, where they meet the alkaliſed nitre and potaſh, with both which they form a ſcoria. The ſilver being capable of reſiſting the action of the nitre, is thus diſengaged from its allay, is fuſed, and collected at the bottom of the crucible.

As the purification of ſilver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with ſwelling and effervescence, the crucibles muſt not be too firmly cloſed, otherwiſe this effervescence might break them, and ſome of the contained matter might be loſt: therefore a ſmall hole is left in the upper crucible, which ſerves as a cover to the other; beſides, the empty ſpace left in the veſſels thus diſpoſed, allows the matter contained to ſwell a little without loſs.

This ſmall hole is alſo very uſeful to ſhew the proper degree of fire during the operation, as has been ſaid. The light and the hiſſing noiſe, which may be perceived when a coal is applied, are occaſioned by part of the nitre which is raiſed up undecompoſed during the detonation. When theſe effects are too conſiderable, and that a ſenſible hiſſing may be heard at the ſmall hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In that caſe the fire muſt be leſſened, otherwiſe much of the nitre would be carried off, and together with it, ſome part of the ſilver, which would be loſt. And even, notwithſtanding all the precautions that can be uſed, this operation can ſcarcely be performed without ſome loſs of the ſilver. Small grains of ſilver are always to be ſeen in the upper crucible, and about the ſmall hole in it. This inconvenience prevents the operation from being employed to determine the value of ſilver, for which purpoſe *cupellation* is therefore uſed.

The purification of ſilver by nitre, has nevertheleſs its peculiar advantages in ſome circumſtances. It is more quick and expeditious than cupellation, and the loſs of ſilver is not conſiderable, when all the proper attentions are obſerved. *See* SILVER, NITRE, *and* DETONATION *of* NITRE.

DLXIX. PURIFICATION *of* GOLD *by* ANTIMONY.

To purify gold from its allays by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of crude antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left ſome minutes in fuſion: after which, when the mixture is well fuſed, and ſo hot that its ſurface ſparkles, it is quickly to be poured into an iron cone, previouſly heated and greaſed. By ſtriking the cone againſt the ground, the deſcent of the regulus will be aſſiſted; and when the cone is cold, it is to be inverted, and the matter taken out. This matter conſiſts of two ſubſtances; the upper one of which is compoſed of the ſulphur of the antimony united with the metals with which the gold was allayed, and the lower is the gold united with a quantity of the regulus of antimony proportionable to the quantity of metals which have been ſeparated from the gold, and which are now united with the ſulphur of the antimony. This regulus of gold may be ſeparated from the ſulphurated metals which cover it; and will be found to be ſo much leſs yellow, that is, mixed with ſo much more regulus of antimony, as the gold was more allayed.

As a ſingle fuſion is not generally ſufficient to diſengage the gold from all its allay, it ought to be fuſed again in the ſame manner, and with the ſame quantity of antimony, and even a third time, if the gold was much allayed. It is fuſible with leſs fire the ſecond and third time than the firſt, from the regulus of antimony which is united with it.

This firſt part of the purification of gold by antimony is founded on a property of ſulphur, by which it is incapable of uniting with gold, and is ſtrongly diſpoſed to unite with all other metallic ſubſtances excepting platina and zinc; and alſo upon this property of ſulphur, that it has leſs affinity with regulus of antimony than with any metallic ſubſtance with which it can unite. Hence when gold allayed with ſilver, copper, iron, lead, &c. is melted together with crude antimony, theſe latter metals unite with the ſulphur of the antimony, while the reguline part, diſengaged by them from its ſulphur, unites with the gold. The ſeparation of metals from gold is then really occaſioned by the ſulphur of the antimony. This purification of gold is conſequently a kind of *dry parting*, but it ſucceeds better than the dry parting by ſulphur alone. The reaſon of this difference is, that ſulphur being very volatile and inflammable, is in great meaſure diſſipated and conſumed, when it is employed alone, before it can ſeize the metals allayed with the gold; whereas when it is already united with a metallic ſubſtance, as it is in the antimony with the reguline part, which prevents it from being quickly conſumed and diſſipated, it may be much more eaſily applied to the metallic ſubſtances allayed with gold. Notwithſtanding this advantage, as a quantity of regulus of antimony is always united with the gold, proportionable to the quantity of metallic ſubſtances ſeparated by means of the ſulphur of the antimony; and as the ſeparation of this regulus from the gold requires much time, as we ſhall ſoon ſee; therefore, when we would purify gold that is much allayed, ſuppoſe under 16 karats, we ought to add along with the antimony ſome pure ſulphur, that we may have a leſs quantity of regulus to ſeparate afterwards from the gold.

When theſe firſt fuſions have been well made, the gold obtained is allayed with only regulus of antimony. But as this ſemi-metal is very volatile and very combuſtible, it may be ſeparated from the gold by a ſufficiently long expoſure to the action of fire. For this purpoſe, the regulus of gold obtained by the former operation is to be put into a large crucible, and heated ſufficiently to keep it in good fuſion. With this heat, the antimony will be diſſipated in ſmoke. If the heat be too ſtrong, ſome of the gold will be carried off with the antimony. The operation therefore muſt be performed ſlowly; and it continues a long time, when much of the regulus of antimony is united with the gold; but it may be abridged by blowing on the ſurface of the metallic maſs, becauſe the application of freſh air accelerates the evaporation of all bodies, and particularly that of the regulus of antimony. When a part of the regulus is diſſipated, more heat is required to keep the metal fuſed, and therefore the fire muſt be encreaſed towards the end of the operation: beſides, when only a ſmall quantity of regulus of antimony remains, it is ſo covered by the gold, and protected from the action of the fire and air, that a ſtronger heat is neceſſary to evaporate it. The ſmoke ceaſes entirely towards the end of the operation, although ſome regulus ſtill remains united with the gold. The purification is compleated by means of a little nitre thrown into the crucible, which effectually calcines the remaining regulus of antimony. Sometimes after theſe operations, the gold is found to be deprived of much of its uſual ductility, which however is eaſily reſtored to it by fuſing it with nitre and borax.

The ancient chemiſts called antimony the *balneum regis*, or the *balneum ſolis*, and the *lupus metallorum*, from this property which it poſſeſſes, of purifying gold. The ſulphur of this mineral does, indeed, ſeize almoſt all the metals with which gold can be allayed; but theſe metals are not deſtroyed, but only reduced to a ſort of mineral ſtate by the ſulphur, forming the ſcoria, from which they may be obtained. Therefore, when the gold contained much allay of ſilver, the ſcoria is very valuable, ſince it contains all the ſilver which was united with the gold. This ſcoria ought to be preſerved and treated like an ore of ſilver, and thus the metal extracted from it. *See* ESSAYS, *and* SMELTING *of* ORES. *See alſo* ANTIMONY, GOLD, SULPHUR.

DLXX. PUTREFACTION. Putrefaction is an inteſtine motion or fermentation excited in the proximate principles of vegetables and animals, by which a decompoſition and total change of the nature of theſe principles are produced, and an alkaline quality is given to the ſaline principles of the compound bodies which ſuffer it.

As putrefaction is a true fermentation, and even is the termination and ultimate degree of all fermentations, therefore all vegetable and animal matters which are fermentable, are alſo capable of putrefaction. Some matters are ſuſceptible of putrefaction only, and not of the two previous degrees of fermentation, namely, the ſpirituous and the acid fermentations. Theſe matters have either already ſuffered the two previous degrees of fermentation, or their principles are diſpoſed by nature in the ſame manner as if they had already ſuffered theſe fermentations: moſt ſubſtances perfectly animaliſed are of this kind.

When fermentable matters of this kind contain a ſufficient quantity of water, when they are expoſed to a ſuitable degree of heat, and have all the requiſite conditions for fermentation in general, they never fail to ſuffer putrefaction. The phenomena accompanying this laſt degree of fermentation are nearly the ſame as thoſe of the two former degrees, excepting that they are leſs ſenſible, at leaſt when the putrefaction proceeds ſlowly. But this ſubject has not been ſufficiently attended to. Mr. Beaumé affirms, that putrefaction is not accompanied with any ſenſible heat. When indeed the putrefaction proceeds ſlowly, and the quantity of putrefying matter is but ſmall, the heat, if any, is very little; but the moſt ſudden and remarkable changes produced upon a body by putrefaction, are upon its color, ſmell, and taſte. Fleſh beginning to putrefy is well known to exhale very ſoon a penetrating fetid ſmell, its color to become livid and black, and its taſte nauſeous. Tranſparent liquors, as urine and broth, during putrefaction, become alſo turbid. As the putrefaction advances, the ſmell becomes more and more fetid, but it alſo acquires great pungency. This pungent ſmell of putrefying matters is very ſenſible in houſes of office, when the weather is changing, particularly before a froſt. This pungency is ſometimes ſo conſiderable that it excites coughing, and draws tears from the eyes. It is cauſed by a large quantity of volatile alkali, which is diſengaged when theſe ſubſtances are completely putrified.

Solid bodies, while they are putrefying, ſwell, become ſoft, loſe the coheſion of their parts, and are laſtly reduced to a very diſguſtful liquor.

From matters completely putrefied may be obtained by diſtillation volatile alkali, ſome liquid and ſome ſolid; pungent, fetid oil, which at firſt is thin, and afterwards becomes more thick; and a reſiduum of coal not eaſily reducible to aſhes. Moſt chemiſts affirm that no fixed alkali is obtained from matters which have undergone a compleat putrefaction; but Mr. Beaumé aſſures us that theſe matters contain fixed alkali ready formed, which may be obtained without fire. This matter requires a more particular examination; perhaps ſeveral ſtages of putrefaction are attended with conſiderable differences in this reſpect.

From the hiſtory of putrefaction we may ſee that this laſt degree of fermentation alters entirely the nature of ſubſtances which ſuffer it, whatever the qualities of their proximate principles may be. By putrefaction they loſe their diſtinctive properties, as they are all converted into volatile alkali, fetid oil, and earth: their organization is deſtroyed, their veſſels, fibres, cells, the very texture of the moſt ſolid parts, are changed, disjoined, and entirely reſolved. All theſe changes are ſpontaneouſly produced upon organized bodies as ſoon as their vital motion ceaſes. As ſoon as vegetables and animals die, nature completes their deſtruction, decompoſes machines now uſeleſs, reduces their materials to a ſimilar and common ſtate; elaborates them again, ſo as to fit them to paſs into the organization of other beings, which alſo muſt afterwards undergo the ſame changes. Thus by an uninterrupted courſe of operations, nature inceſſantly renews the life of beings, which, notwithſtanding the old age and deaths of individuals, is ſuſtained in perpetual vigor and youth, as has been obſerved by one of our moſt eloquent modern philoſophers.

We have already remarked that the nature and phenomena of putrefaction have been but too little examined hitherto. We ſhall add here, that whatever attention may be given to this ſubject, we ſhall perhaps be never able to know more than the beginnings of this operation, and even a ſmall part only of theſe. In fact, putrefaction ſeems to be a very extenſive operation, and its laſt ſtage ſeems in ſome meaſure out of our reach. We conſider that a matter is entirely putrefied, when nothing remains but earth, or the fixed parts of it. But theſe coarſe materials are the leaſt part of thoſe which compoſe organiſed bodies. The exiſtence even of theſe reſiduums deprived of all other principles, the volatility of the ſaline and oily principles which are continually exhaling and diſſipating during putrefaction, ſhew that nature is inceſſantly, during this operation, attenuating, ſubtilizing, volatilizing, and carrying off all it can of theſe bodies; and all the ſubſtances, thus elaborated and carried off, are removed from the reach and obſervation of our ſenſes. We do not know, and probably we never ſhall know, what further changes they ſuffer, before they enter into the combination of new beings.

But if the compleat theory of putrefaction be very difficult, it is alſo very important, as it ſeems to be the true key of the moſt eſſential and hidden ſecrets of the animal economy. In fact, as the proper ſubſtance of all the parts of the bodies of animals differs from vegetable matters, (by which all animals are mediately or immediately nouriſhed) in this circumſtance, that they are much nearer the ſtate of putrefaction, we have reaſon to believe that the change of vegetable into animal matters is principally produced by a kind of fermentation, or even by a beginning, ſlow, and imperceptible putrefaction. In this point, certainly, perfect *animaliſation* conſiſts; and conſequently the animal economy cannot fail of being deranged, and reduced to a morbid ſtate, whenever this animaliſation, or imperceptible putrefaction, (for I do not ſcruple to give it that name) becomes too much or too little: which truth is well perceived by the great Boerhaave in his aphoriſms concerning the diſeaſes proceeding from ſpontaneous acids and alkalis.

Theſe conſiderations are certainly ſufficient to induce chemiſts and phyſicians to acquire all the knowledge they can on this ſubject. The firſt trials to be made in this way, and from which the greateſt certainty and utility may be expected, are reſearches to ſhew what ſubſtances accelerate and retard putrefaction. Meſſrs. Pringle and Macbride have made the firſt ſteps, and have publiſhed the intereſting experiments which they have made on this ſubject, which is very far from being exhauſted. I know that a very able French experimental philoſopher has finiſhed a numerous ſet of well made experiments on this ſubject, which he propoſes ſoon to publiſh. *See* FERMENTATION. *(b)*

(*b*) To the above article we make the following additions.

1. Putrefaction, as alſo fermentation in general, ſeem to conſiſt not merely in the decompoſition and tranſpoſition of the particles of the putrefying or fermenting matter, by which new combinations are produced, but alſo in the extrication and expulſion of ſome of the conſtituent parts of theſe matters. The conſtituent part, thus extricated and expelled by putrefaction and fermentation, is a permanently elaſtic vapor, or fixable air. A part of the air extracted from putrefying ſubſtances was found by Mr. Cavendiſh's experiments to be inflammable. *See* AIR, (FIXABLE). And from the experiments of Dr. Macbride, which ſhew that cauſtic alkali and quicklime may be rendered mild, or combined with air, by abſorbing the elaſtic vapor extricated from putrefying and fermenting ſubſtances, we have reaſon to believe that another part of the vapor extricated from theſe ſubſtances is of the uninflammable kind of fixable air which combines with alkaline ſalts and earths. *See* AIR (FIXABLE) *and* QUICKLIME.

Dr. Hales believes that this air is the principal cauſe of coheſion and ſolidity of bodies. He remarks that air abounds much more in ſolid than in liquid bodies, and that ſolid bodies being generally denſer than water, the attraction of the air of theſe ſolid bodies, in a fixed ſtate, and its repulſion when in an elaſtic ſtate, are greater than the attraction and repulſion of the lighter watery particles in a fixed and in an elaſtic ſtate; and hence the particles of air are fitter to be the principal band of union in ſolid bodies, than the particles of water. That Sir Iſaac Newton had entertained a ſimilar opinion, appears from the following paſſage in the third book of his Optics. "The particles of fluids
" which do not cohere too ſtrongly, and are
" of ſuch a ſmallneſs as renders them moſt
" ſuſceptible of thoſe agitations which keep
" liquors in a fluor, are moſt eaſily ſeparated and rarefied into vapor, and, in the
" language of the chemiſts, they are volatile, rarefying with an eaſy heat, and condenſing with cold. But thoſe which are
" groſſer, and ſo, leſs ſuſceptible of agitation, or cohere by a ſtronger attraction,
" are not ſeparated without a ſtronger heat,
" or perhaps not without fermentation. And
" theſe laſt are the bodies which chemiſts
" call *fixed*, and being rarified by fermentation become true permanent air;
" thoſe particles receding from one another
" with the greateſt force, and being moſt
" difficultly brought together, which upon
" contact cohere moſt ſtrongly. And becauſe
" the particles of permanent air are groſſer,
" and ariſe from denſer ſubſtances than thoſe
" of vapors, thence it is that true air is
" more ponderous than vapor, and that a
" moiſt atmoſphere is lighter than a dry
" one, quantity for quantity."

Dr. Macbride alſo maintains this opinion, and further endeavors to ſhew, that without the extrication of this air, no putrefaction can happen, and even that by abſorption of it, putrefied ſubſtances may be corrected and rendered ſweet. Having expoſed putrid matters to the vapors ariſing from ferment-

DLXXI. PYRITES. Pyrites is a mineral reſembling the true ores of metals, in the ſubſtances of which it is compoſed, in its color or luſtre,

ing mixtures, or from alkaline ſubſtances effervescing with acids, he found the putrid quality was deſtroyed; and hence he conſiders this air as powerfully antiſeptic.

2. Contact of atmoſpherical air is ſaid to be neceſſary to putrefaction; and Mr. Boyle relates that he has preſerved lemons, oranges, and other fruits, from putrefaction, or other fermentation, during ſeveral years, by including them in an inexhauſted receiver. Dr. Macbride found that putrefaction was accelerated by encloſing a piece of fleſh in an exhauſted receiver; but that another piece continued ſweet, which was included in an exhauſted hollow braſs ſphere, conſiſting of two hemiſpheres joined together. He conjectures that the cauſe of this difference might be, that in the latter experiment the vacuum was more perfect than in the former, as the glaſs receiver did not ſeem to exclude with ſufficient accuracy the external air, and that tho' a partial vacuum may accelerate putrefaction, yet ſome air may be neceſſary to this proceſs.

It is well known that bodies are preſerved from putrefaction by covering them with wax, ſuet, &c. Whether is this effect produced merely by excluding external air, or alſo by preventing the extrication of the internal fixable air?

3. Sir John Pringle has made experiments to determine the powers of certain ſubſtances to promote or to prevent putrefaction. From theſe experiments he has formed the following table, ſhewing the relative antiſeptic powers of the ſaline ſubſtances mentioned. Having found that two drams of beef put in a phial with two ounces of water, and placed in a heat equal to 90 degrees of Fahrenheit's thermometer, became putrid in 14 hours, and that ſixty grains of ſea-ſalt preſerved a ſimilar mixture of beef and water more than 30 hours, he made the antiſeptic power of the ſea-ſalt a ſtandard, to which he compared the powers of the other ſalts. The algebraic character + ſignifies that the ſubſtance to which it is annexed had a greater antiſeptic power than is expreſſed by the numbers.

Sea-ſalt, or the ſtandard	1
Sal-gem	1 +
Vitriolated tartar	2
Spiritus Mindereri	2
Soluble tartar	2
Sal diureticus	2 +
Crude ſal ammoniac	3
Saline mixture	3
Nitre	4 +
Salt of hartſhorn	4 +
Salt of wormwood	4 +
Borax	12
Salt of amber	20
Alum	20

N. B. The quantities of ſpiritus Mindereri and of the ſaline mixture were ſuch, that each of them contained as much alkaline ſalt as the other neutral ſalts.

Myrrh, *aloes*, *aſſafetida*, and *terra Japonica*, were found to have an antiſeptic power 30 times greater than the ſtandard. *Gum ammoniacum*, and *ſagapenum*, ſhewed little antiſeptic power.

Of all reſinous ſubſtances, *camphor* was found to reſiſt putrefaction moſt powerfully. Sir John Pringle believes that its antiſeptic power is 300 times greater than that of ſea-ſalt.

Chamomile flowers, *Virginian ſnake-root*, *pepper*, *ginger*, *ſaffron*, *contrayerva root*, and *galls*, were found to be 12 times more antiſeptic than ſea-ſalt.

Infuſions of large quantites of *mint*, *angelica*, *ground-ivy*, *green tea*, *red roſes*, *common wormwood*, *muſtard*, and *horſe-radiſh*, and alſo decoctions of *poppy-heads*, were more antiſeptic than ſea-ſalt.

Decoctions of *wheat*, *barley*, and other *farinaceous grains*, checked the putrefaction by becoming ſour.

Chalk, and other *abſorbent powders*, accelerated the putrefaction, and reſolved meat into a perfect mucus. The ſame powders prevented an infuſion of farinaceous grains from becoming mucilaginous and ſour.

One dram of *ſea-ſalt* was found to preſerve two drams of freſh beef in two ounces of water, above 30 hours, uncorrupted, in a heat equal to that of the human body, or above 20 hours longer than meat is preſerved in water without ſalt: but half a dram of ſalt did not preſerve it more than two hours longer than pure water. Twenty-five grains of in its great weight, and, laſtly, in the parts of the earth in which it is found, ſince it almoſt always accompanies ores. It is, like ores, compoſed of metallic ſubſtances, mineraliſed by ſulphur or by arſenic, or by both theſe matters, and of an unmetallic earth intimately united with its other principles.

Notwithſtanding the conformity of pyrites with ores properly ſo called, chemiſts and metallurgiſts diſtinguiſh the former from the latter minerals;

of ſalt had little or no antiſeptic quality. Twenty grains, fifteen grains, but eſpecially ten grains only of ſea-ſalt were found to accelerate and heighten the putrefaction of two drams of fleſh. Theſe ſmall quantities of ſea-ſalt did alſo ſoften the fleſh more than pure water.

The ſame ingenious phyſician made experiments to diſcover the effects of mixing vegetable with animal matters.

Two drams of raw-beef, as much bread, and an ounce of water, being beat to the conſiſtence of pap, and expoſed to 90° of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in fermentation during two days. When it began to ferment and ſwell, the putrefaction had begun; and in a few hours afterwards, the ſmell was offenſive. Next day the putrid ſmell ceaſed, and an acid taſte and ſmell ſucceeded. Freſh alimentary vegetables, as ſpinnage, aſparagus, ſcurvy-graſs, produced ſimilar effects as bread on fleſh, but in a weaker degree. From ſeveral other experiments he found that animal ſubſtances excite the fermentation of vegetable ſubſtances, and that the latter ſubſtances correct the putreſcency of the former.

By adding *ſaliva* to a ſimilar mixture of fleſh, bread, and water; the fermentation was retarded, moderated, but rendered of twice the uſual duration, and the acid produced at laſt was weaker than when no ſaliva was uſed.

By adding an *oily ſubſtance* to the common mixture of fleſh, bread and water, a ſtronger fermentation was produced, which could not be moderated by the quantity of ſaliva uſed in the former experiment, till ſome *fixed alkaline ſalt* was added, which ſalt was found, without ſaliva, to ſtop ſuddenly very high fermentations.

He did not find that *ſmall quantities* of the following ſalts, *ſal ammoniac*, *nitre*, *vitriolated tartar*, *ſal diureticus*, *ſalt of hartſhorn*, *ſalt of wormwood*, were ſeptic, as ſmall quantities of ſea-ſalt were.

Sugar was found to reſiſt putrefaction at firſt, as other ſalts do, and alſo to check the putrefaction after it had begun by its own fermentative quality, like bread and other fermentative vegetables.

Lime-water made ſome ſmall reſiſtance to putrefaction.

Port wine, *ſmall-beer*, infuſions of *bitter vegetables*, of *bark*, and the juice of *antiſcorbutic plants*, retarded the fermentation of mixtures of fleſh and bread. But an *unſtrained decoction of bark* conſiderably encreaſed that fermentation.

Crabs-eyes accelerated and encreaſed the fermentation of a mixture of fleſh and bread.

Lime water neither retarded nor haſtened the fermentation of ſuch a mixture: but when the fermentation ceaſed, the liquor was neither putrid nor acid, but ſmelt agreeably.

Fleſh pounded in a mortar was found to ferment ſooner than that which had not been bruiſed.

The tough inflammatory cruſt of *blood* was found to be moſt putreſcent, next to which the craſſamentum, or red coagulated maſs, and laſtly the ſerum.

Dr. Macbride's experiments confirm many of theſe above related, eſpecially thoſe which ſhew that the fermentation of vegetable ſubſtances is encreaſed by a mixture of animal or putreſcent matter; that the putreſcency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable ſubſtances were accelerated by additions of abſorbent earths and of Peruvian bark: He alſo found that altho' unburnt calcareous earths were ſeptic, quicklime and lime-water prevented putrefaction, but that they deſtroyed or diſſolved the texture of fleſh.

The experiments of the author of the *Eſſai pour ſervir à l'Hiſtoire de la Putrefaction* ſhew that metallic ſalts, reſinous powders, extracts of bark, and opium, are very powerfully antiſeptic, and that ſalts with earthy baſes are leſs antiſeptic than any other ſalts.

and they do this with propriety, becauſe the proportion and connexion of the materials compoſing the pyrites differ much from thoſe of ores.

Altho' ſometimes pyrites contains more metal than ſome ores, yet generally it contains leſs metal, and a larger quantity of mineraliſing ſubſtances, ſulphur and arſenic, and particularly of unmetallic earth. The connexion of theſe matters is alſo much ſtronger in pyrites than in ores, and they are accordingly much harder; ſo that almoſt every pyrites can ſtrike ſparks from ſteel. From this property of ſtriking ſparks from ſteel they have been called pyrites, which is a Greek word ſignifying *fire ſtone*. Pyrites was formerly uſed for fire-arms, as we now uſe flints; hence it was called *carabine-ſtone*. It is ſtill named by ſome, *marcaſite*. Perhaps no other kind of natural body has received ſo many names. Perſons curious to know the other names leſs uſed than thoſe we have mentioned, may find them in *Henckel's Pyritologia*. We think, with that celebrated chemiſt, that the ſubject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confuſed and inaccurate.

Pyrites differs alſo from ores by its forms and poſitions in the earth. Altho' pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly ſpeaking, themſelves form the oblong and continued maſſes called veins, as ores do, but they form maſſes ſometimes greater and ſometimes ſmaller, but are always diſtinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalk, marles, marbles, plaſters, alabaſters, ſlates, ſpars, quartz, granites, cryſtals, in a word, in all earths and ſtones. Many of them are alſo found in pit-coals and in other bituminous matters.

Pyrites is alſo diſtinguiſhable from ores by its luſtre and figure, which is almoſt always regular and uniform, externally or internally, or both. Some ores indeed, like thoſe of lead, many ores of ſilver, and ſome others, have regular forms, and are in ſome manner cryſtallized; but this regularity of form is not ſo univerſal, and ſo conſpicuous in ores as in pyrites. The luſtre of pyrites ſeems to be cauſed by its hardneſs, and the regularity of its form by the quantity of mineraliſing ſubſtances which it contains.

By all theſe marks we may eaſily, and without analyſis, diſtinguiſh pyrites from true ores. When we ſee a mineral that is heavy, poſſeſſed of metallic luſtre, and of any regular form, the maſs of which appears evidently to be entire, that is, not to have been a fragment of another maſs, and which is ſo hard as to be capable of ſtriking ſparks from ſteel, we may be aſſured that ſuch a mineral is a pyrites, and not an ore.

The claſs of pyrites is very numerous, various, and extenſive. They differ one from another in the nature and proportions of their component parts, in their forms and in their colors. The forms of theſe minerals are exceedingly various. No ſolid regular or irregular can eaſily be conceived that is not perfectly imitated by ſome kind of pyrites. They are ſpherical, oval, cylindrical, pyramidal, priſmatical, cubic; they are ſolids with 5, 6, 7, 8, 9, 10, &c. ſides. The ſurface of ſome is angular, and conſiſts of many baſes of ſmall pyramids; while their ſubſtance is compoſed of theſe pyramids, the points of which all unite in the center of the maſs.

Pyritous minerals differ alſo in their component ſubſtances. Some of them are called ſulphureous, martial, cupreous, arſenical, as one or other of theſe ſubſtances predominate. We muſt obſerve with Henckel, whoſe authority is very great in this ſubject, that in general all pyrites are martial, as ferruginous earth is the eſſential and fundamental part of every pyrites. This earth is united with an unmetallic earth, with ſulphur or arſenic, or with both theſe matters; in which caſe, the ſulphur always predominates over the arſenic, as Henckel obſerves. He conſiders theſe as the only eſſential principles of pyrites, and believes that all the other matters, metallic or unmetallic, which are found in it, are only accidental; amongſt which he even includes copper, although ſo much of it exiſts in ſome kinds of pyrites, that theſe are treated as ores of copper, and ſometimes contain even 50lb. of copper each quintal. Many other metals, even gold and ſilver, are ſometimes combined in pyrites; but theſe are leſs frequent, and the precious metals always in very ſmall quantities; they are therefore juſtly to be conſidered as accidental to pyrites. The different ſubſtances compoſing pyrites ſenſibly affect its colors. Henckel diſtinguiſhes them in general into three colors, white, yellowiſh or a pale yellow, and yellow. He informs us, that theſe three colors are often ſo blended one with another, that they cannot be eaſily diſtinguiſhed, unleſs when compared together.

The white pyrites contain moſt arſenic, and are ſimilar to cobalt and other minerals abounding in arſenic. The Germans call them *miſpickel* or *miſpilt*. Iron and arſenic form the greateſt part of this pyrites. As arſenic has the property of whitening copper, ſome pyritous minerals almoſt white, like that of Chemnitz, in Miſnia, are found to contain forty pounds of copper per quintal, and which are ſo much whitened by the arſenic, that they are very like white pyrites. But Henckel obſerves, that theſe pyritous matters are very rare, and are never ſo white as the true white pyrites, which is only ferruginous and arſenical.

Yellowiſh pyrites is chiefly compoſed of ſulphur and iron. Very little copper and arſenic are mixed with any pyrites of this color, and moſt of them contain none of theſe two metallic ſubſtances. This is the moſt common kind of pyrites: it is to be found almoſt every where. Its forms are chiefly round, ſpherical, oval, flattened, cylindrical, and it is compoſed internally of needles or radii, which unite in the center or in the axis of the ſolid.

Yellow pyrites receives its color from the copper and ſulphur which enter into its compoſition. Its color, however, is inclined to a green, but is ſufficiently yellow to diſtinguiſh it from the other two kinds of pyrites, particularly when they are compared together. To make this compariſon well, the pyrites muſt be broken, and the internal ſurfaces muſt be placed near each other. The reaſon of this precaution is, that the color of minerals is altered by expoſure to the air.

Perſons accuſtomed to theſe minerals can eaſily diſtinguiſh them. The chief difficulty is to diſtinguiſh white pyrites from cobalt and other minerals, which alſo contain ſome copper and much arſenic.

Hence then we ſee, that arſenic is the cauſe of whiteneſs in pyrites, and is contained in every pyrites of that color; that copper is the principal cauſe of the yellow color of pyrites; and that every pyrites which is evidently yellow contains copper; that ſulphur and iron produce a pale-yellow color, which is alſo produced by copper and arſenic; hence ſome difficulty may ariſe in diſtinguiſhing,

guiſhing pyrites by its colors. We may alſo obſerve, that ſulphur and arſenic, without any other ſubſtance, form a yellow compound, as we ſee from the example of orpiment or yellow arſenic. Thus, although the colors of the pyrites enable us to diſtinguiſh its different kinds, and to know their nature at firſt ſight, particularly when we have been accuſtomed to obſerve them; yet we cannot be entirely certain concerning the true nature of theſe minerals, and even of all minerals in general, that is, to know preciſely the kinds and proportions of their component ſubſtances, but by chemical analyſis and decompoſition.

Beſides the above-mentioned matters which compoſe pyrites, it alſo contains a conſiderable quantity of unmetallic earth, that is, an earth which cannot by any proceſs be reduced to metal. Henckel, Cramer, and all thoſe who have examined this matter, mention this earth, and prove its exiſtence.

We ought to obſerve, that this earth is combined with the other principles of the pyrites, and not merely interpoſed betwixt its parts. It muſt therefore be diſtinguiſhed from other earthy and ſtony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, ſince they may be ſeparated by mechanical means, and without decompoſing that mineral: but the earth of which we now treat is intimately united with the other conſtituent parts of the pyrites, is even a conſtituent part of pyrites, and eſſential to the exiſtence of this mineral, and cannot be ſeparated but by a total decompoſition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, ſince he found from the analyſes which he made, that the iron, which is the only metal exiſting in theſe pyrites, is only about $\frac{1}{20}$th part of the fixed ſubſtance that remains after the arſenic has been expelled by torrefaction or ſublimation.

A much larger quantity of iron is in the pale-yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and ſometimes fifty or ſixty pounds: this is therefore called martial pyrites. It contains about $\frac{1}{4}$ of its weight of ſulphur, and the reſt is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are alſo martial, ſince, as we have obſerved, iron is an eſſential part of every pyrites, has not yet been determined. They probably contain ſome of that earth, though perhaps leſs of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks that it is an earth diſpoſed already by nature to metallization, but not ſufficiently elaborated to be conſidered as a metallic earth. *See the articles* METALS *and* METALLISATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not ſuſpect that this unmetallic earth is of the nature of the baſis of alum or argillaceous earth? *See* ALUM *and* CLAY. Perhaps alſo this earth is different in different kinds of pyrites. The ſubject deſerves to be well examined.

Although pyrites is not ſo valuable as true ores, becauſe in general it contains leſs metal, and but exceedingly little of the precious metals; and becauſe its metallic contents are ſo difficult to be extracted, that, excepting cupreous pyrites, which is called *pyritous copper ore*, it is not worked for the ſake of the contained metal; yet it is applied to other purpoſes, and furniſhes us with many uſeful ſubſtances; for from it we obtain all our green and blue vitriols, much ſulphur, arſenic, alum, and orpiment. *See the principal proceſſes by which theſe ſubſtances are extracted from pyrites, under the article* Smelting *of* Ores.

As every pyrites contains iron, and moſt of them contain alſo ſulphur; as the pyrites moſt frequently found contains only theſe two ſubſtances with the unmetallic earth; and as iron and ſulphur have a ſingular action upon each other, when they are well mixed together and moiſtened; hence many kinds of pyrites, particularly thoſe which contain only the principles now mentioned, ſuſtain a ſingular alteration, and even a total decompoſition, when expoſed during a certain time to the combined action of air and water. The moiſture gradually penetrates them, divides and attenuates their parts; the acid of the ſulphur particularly attacks the martial earth, and alſo the unmetallic earth, its inflammable principle is ſeparated from it, and is diſſipated. While theſe alterations happen, the pyrites changes its nature. The acid of the ſulphur which is decompoſed forms with the fixed principles of the pyrites, vitriolic, aluminous, and ſelenitic ſalts; ſo that a pyrites which was once a ſhining, compact, very hard mineral, becomes in a certain time a greyiſh, ſaline, powdery maſs, the taſte of which is ſaline, auſtere, and ſtiptic.

Laſtly, if this maſs be lixiviated with water, cryſtals of vitriol, and ſometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and cryſtallization.

This alteration and ſpontaneous decompoſition of pyrites is called *effloreſcence* and *vitrioliſation*; becauſe the pyrites becomes covered with a ſaline powder; and becauſe vitriol is always formed. This vitrioliſation is more or leſs quickly accompliſhed in pyrites according to its nature. It is a kind of fermentation excited by moiſture amongſt the conſtituent parts of theſe minerals; and it is ſo violent in thoſe which are moſt diſpoſed to it, that is, in the pale-yellow pyrites, which contain chiefly ſulphur and iron, that when the quantity of theſe is conſiderable, not only a ſulphureous vapor and heat may be perceived, but alſo the whole kindles and burns intenſely. The ſame phenomena are obſervable, and the ſame reſults are formed, by mixing well together and moiſtening a large quantity of filings of iron and powdered ſulphur: which experiment Lemeri has made, to explain the cauſes of ſubterranean fires and volcanos

We cannot doubt that, as the earth contains very large maſſes of pyrites of this kind, they muſt undergo the ſame changes when air and moiſture penetrate the cavities containing them; and the beſt natural philoſophers agree, that very probably this ſurprizing decompoſition of pyrites is the cauſe of ſubterranean fires, of volcanos, and of mineral waters, vitriolic, aluminous, ſulphureous, hot and cold.

No other pyrites is ſubject to this ſpontaneous decompoſition, when expoſed to humid air, but that which is both martial and ſulphureous, that is, the pale yellow pyrites. The arſenical pyrites, or that which contains little or no ſulphur, is not changed by expoſure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly ſhaped, is chiefly of this kind. Mr. Wallerius, in his Mineralogy, propoſes to diſtinguiſh this kind of pyrites by the name of *marcaſite*. When cut, it may be poliſhed ſo well as to give a luſtre almoſt equal to that of diamonds, but without refracting or decompoſing the light; for it is perfectly opake. It has been employed ſome years paſt in the manufacture of toys, as of buckles, necklaces, &c and is called in commerce *marcaſite*. *See* WATERS (MINERAL), ORES, SMELTING *of* ORES. (*i*)

DLXXII PYROPHORUS *of* HOMBERG. The Pyrophorus is a chemical preparation, which has the ſingular property of kindling ſpontaneouſly when expoſed to air. It was accidentally diſcovered by Mr. Homberg. This chemiſt was endeavouring to extract a limpid and flavorleſs oil from human ordure, which ſhould have the property of fixing mercury (*ſee* EXCREMENTS *of* ANIMALS); and when he had mixed the ſubſtance upon which he was operating with different matters, he was much ſurprized, while he was taking the caput mortuum of one of theſe mixtures out of a retort, four or five days after it had been operated upon, to ſee it kindle and burn ſtrongly as ſoon as it was expoſed to air. He recollected that this was the reſiduum of a mixture of alum and human feces from which he had obtained all that he could by means of a red-heat. He repeated the proceſs, and obtained from it the ſame reſult. When he was well aſſured of it, he publiſhed his diſcovery. Human feces were a long time believed to be eſſential to the operation, till the youngeſt ſon of the great Lemeri found, that honey, ſugar, flour, in a word, any animal or vegetable matter, might be ſubſtituted in place of the human feces; and ſince that time, Mr. Lejay de Suvigny, Doctor of Phyſic, a perſon well verſed in mathematical and phyſical ſciences, has communicated to the Academy a Memoir, relating experiments made on the pyrophorus, in which he generaliſes the proceſs, and gives the true theory of it. He there ſhews, that moſt vitriolic ſalts may be ſubſtituted for the alum; which diſcovery aſſiſted him greatly in explaining the theory of the operation. This Memoir is printed in the third volume of the Collection of Memoirs by correſpondents of the Academy.

(*i*) I do not know any ſufficient reaſon for conſidering the minerals called *pyrites* as a diſtinct claſs of ſubſtances from ores. They have indeed no mark by which they can certainly and conſtantly be diſtinguiſhed from theſe. The hardneſs or property of ſtriking ignited ſparks from ſteel is not common to all the ſubſtances generally called pyrites; for we find ſome of theſe enumerated by mineralogiſts which have not that property. Wallerius even mentions a pyrites which contains no iron, although that metal is thought by Henckel to be eſſential to pyrites. The diſtinction of pyrites from ores has been chiefly introduced by miners; becauſe the greateſt part of the former minerals contain ſo little metal, and ſo much of the mineraliſing ſubſtances, ſulphur, or arſenic, that they are ſeldom ſmelted. Nevertheleſs, ſome kinds of pyrites are found which contain ſo much copper, that they are ſmelted with great profit. Accordingly, ſome later mineralogiſts conſider the cupreous yellow pyrites as an ore of copper, the pale-yellow martial pyrites as an ore of iron, and the white arſenical pyrites as an ore of arſenic. *See* ORES *of* COPPER, IRON, *and of* ARSENIC.

Although alum is not abſolutely neceſſary for the preparation of the pyrophorus, yet it is one of the vitriolic ſalts which ſucceeds beſt. The following proceſs is very good for this preparation.

Let three parts of alum and one part of ſugar be mixed together. This mixture muſt be dried in an iron ſhovel over a moderate fire, till it be almoſt reduced to a blackiſh powder of coal, during which it muſt be ſtirred with an iron ſpatula. Any large maſſes muſt be bruiſed into powder, and then it muſt be put in a glaſs matraſs, the mouth of which is rather ſtrait than wide, and ſeven or eight inches long. This matraſs is to be placed in a crucible, or other earthen veſſel, large enough to contain the belly of the matraſs, with about a ſpace equal to the thickneſs of a finger all round it. This ſpace is to be filled with ſand, ſo that the matraſs ſhall not touch the earthen veſſel: the apparatus is then to be put in a furnace, and the whole to be made red-hot: the fire muſt be gradually applied, that any oily or fuliginous matter may be expelled. After which, when the matraſs is made red-hot, ſulphureous vapors exhale: This degree of heat is to be continued till a truly ſulphureous flame, which appears at the end of the operation, has continued nearly a quarter of an hour: the fire is then to be extinguiſhed, and the matraſs to cool without taking it out of the crucible; and when it ceaſes to be red-hot, it muſt be ſtopped with a cork. Before the matraſs is perfectly cold, it muſt be taken out of the crucible, and the powder it contains muſt be poured into a very dry glaſs phial, which muſt be well cloſed with a glaſs ſtopper. If we would preſerve this pyrophorus a long time, the bottle containing it muſt be opened as ſeldom as is poſſible. Sometimes it kindles while it is poured into the glaſs phial, but it may be then extinguiſhed by cloſing the phial expeditiouſly.

When half a dram of this pyrophorus is put on a piece of paper and expoſed to air, it quickly kindles, becomes red like burning coals, emits a ſtrongly ſulphureous vapor, and burns the paper or other combuſtible body which ſupports it.

This preparation has hitherto been uſed only to entertain curious perſons with a ſight truly ſurprizing, of a ſubſtance which contains within itſelf a principle of fire capable of burning ſpontaneouſly, and which being more inflammable than any other ſubſtance known, kindles without contact of an ignited matter. The phenomena which it exhibits confirm Stahl's theory concerning the compoſition of ſulphur, and give a ſtriking proof of the almoſt incredible force and activity with which the vitriolic acid, when highly concentrated, but not perfectly combined, unites with the moiſture of the air.

In the firſt place, we cannot doubt that ſulphur is formed in the operation of the pyrophorus; for the experiments made by Stahl demonſtrate, that the vitriolic acid engaged in any baſis quits that baſis, and unites with the inflammable principle whenever the circumſtances neceſſary for that union concur; as they all do in this caſe; and therefore ſulphur muſt be really formed. Beſides, although we had not this proof of it, the ſulphureous flame ſeen above the matraſs in which the pyrophorus is made, the peculiar ſmell of ſulphur which the pyrophorus when burning exhales, and, laſtly, the poſſibility of obtaining ſulphur ready formed, would ſufficiently demonſtrate this truth. *See* SULPHUR.

In the ſecond place, probably the whole vitriolic acid of the alum is not employed to form ſulphur in the operation of the pyrophorus; not becauſe a ſufficient quantity of inflammable principle is not contained in the vegetable or animal matter with which it is mixed; but rather becauſe a ſufficient time is not given for that purpoſe, as we ſhall preſently ſee.

Theſe preliminary remarks being made, we obſerve, that probably the portion of vitriolic acid of the alum, which has not had time to form perfect ſulphur, being partly diſengaged from the earth by the action of fire, and by the preſence of the inflammable principle; and being alſo greatly dephlegmated, ſince it is in a dry ſtate; is capable of uniting with the moiſture of the air as ſoon as it is expoſed to it; and with ſuch activity, that a heat is produced ſufficient to kindle the ſulphur and a very combuſtible fuliginous matter which are contained in the pyrophorus. This is the explanation given by Mr. Lejay de Suvigny; and is confirmed by the following obſervations.

Firſt, the pyrophorus can be made only with ſubſtances fit for producing ſulphur, or with ſulphur itſelf, as Mr. de Suvigny has ſhewn.

Secondly, no pyrophorus will be produced, if the mixture be calcined by too long or too violent a fire; becauſe then the whole vitriolic acid can be combined into perfect ſulphur, and conſequently is engaged, and not in a proper ſtate to attract the moiſture of the air; or elſe if it does not combine into ſulphur, it being half diſengaged from its baſis, is driven off by the violence or long continuance of the fire; and, conſequently, after this compleat calcination, no acid remains partly diſengaged, as it ought to be, that it might unite with the water with ſufficient activity.

Thirdly, when the pyrophorus is very ſlowly moiſtened, as when it is kept in a bottle not well cloſed, it does not kindle, becauſe ſufficient heat is not produced by this ſlow and gradual attraction of water. It is alſo ſpoiled and rendered incapable of kindling, when expoſed to the open air; becauſe its acid becomes then ſaturated or nearly ſaturated with moiſture, and cannot therefore unite with that of the air with ſufficient activity.

Fourthly, a pyrophorus thus ſpoiled by expoſure to moiſture may be reſtored to its peculiar properties by making it again red-hot in a matraſs; ſince by this calcination its partly diſengaged acid is again concentrated, and reſumes all its force of combining with water.

Fifthly, the inflammation of the pyrophorus is accelerated by placing it upon paper a little wetted, or by breathing upon it; becauſe the acid then attracts the moiſture more haſtily, and conſequently with more heat.

All theſe facts clearly prove, that the pyrophorus is inflamed by the extreme heat excited in its parts, from the ſingular force and activity with which it ſeizes moſture. But further, as Mr. de Suvigny well remarks, the pyrophorus can only contain the baſis of the vitriolic ſalt employed, the earth of the vegetable or animal ſubſtance which furniſhed the inflammable matter, a coal, ſome perfect ſulphur, and ſome imperfectly formed ſulphur or vitriolic acid, which is but imperfectly engaged either by its baſis or by phlogiſton. Now of all theſe ſubſtances, the acid only, which is alſo very concentrated, can attract moiſture ſo forcibly as to produce great heat. To this portion then of vitriolic acid we muſt attribute the ſpontaneous inflammation of the pyrophorus. *See* ACID (VITRIOLIC), PHLOGISTON, *and* SULPHUR.

DLXXIII. PYROTECHNICKS. This Greek name, ſignifying the *art of fire*, has been given to chemiſtry, becauſe moſt chemical operations are made by fire: but it is now confined to the art of compoſing fire-works. *See* POWDER (GUN).

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DLXXIV. QUARTATION. Quartation is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus when gold allayed with ſilver is to be parted, we are obliged to facilitate the action of the aqua fortis by reducing the quantity of the former of theſe metals to one fourth part of the whole maſs; which is done by ſufficiently encreaſing the quantity of the ſilver, if it be neceſſary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. *See* PARTING.

DLXXV. QUARTZ. Quartz is a hard vitrifiable ſtone, ſomething intermediate betwixt rock-cryſtals and flints, or opake vitrifiable ſtones. Quartz is a ſtone well known by metallurgiſts, mineralogiſts, and miners, as it is frequently and abundantly found with ores, of which it often forms the matrix. It is alſo frequently found where no ores are.

The moſt common quartz is more or leſs of a milky-white color, and conſequently ſemi-tranſparent. Some of them have various colors. This ſtone, which is very hard and very compact, is nevertheleſs cracked throughout its ſubſtance; to which alſo the rock-cryſtal is very liable, but much leſs ſo than quartz. The fragments of quartz are always angular, and its internal ſurface has but little gloſs. Quartz is a little waved, and has a greaſy appearance. It is found not only of various colors but alſo of various forms. It is frequently found cryſtallized in caverns and ſlits of rocks. Its cryſtallization is the ſame as that of rock-cryſtal. Quartz may be employed in vitrification, as all other vitrifiable ſtones are. *See* EARTHS (VITRIFIABLE) *for the nature and properties of quartz; and alſo the mineralogy of Wallerius, and the Dictionnaire d'Hiſtoire Naturelle de M. Bomare, for the different kinds of it.*

(*k*) Quartz is a ſtone of the kind called by authors *ſiliceous* or *vitrifiable*. Some of theſe ſtones conſiſt of impalpable particles, others have a granulated texture, and laſtly ſome have a ſparry or laminated texture. When pure, they are white and opake, or

DLXXVI. QUICKLIME. This name is given to all the earths and ſtones which have acquired, by expoſure to a certain heat, the following properties. [*Concerning the properties of theſe earths before calcination, ſee the article* EARTH (CALCAREOUS)].

Theſe ſtones by calcination loſe half of their former weight, and much of their hardneſs. This alteration ſhews that the calcareous ſtones, before calcination, are not a pure earth, but a compound of a fixed earthy matter and of ſome volatile ſubſtance, of which they may be deprived by fire.

After the calcination has been completed, and the ſtones are become cold, if water be applied to them, it penetrates them with conſiderable heat and violence, divides and ſeparates their parts, and reduces them to a very fine paſte, if the quantity of water added has not been too great. The paſte of quicklime thus ſlaked ſtrongly retains the water, and when mixed with ſand or with pounded baked clay, it becomes very hard in a certain time. This mixture is called *mortar*.

The water employed to ſlake the quicklime diſſolves a part of it, and is called *lime water*. When this water is expoſed to evaporation, a ſemi-cryſtalline pellicle is formed on its ſurface, which is the diſſolved quicklime: this pellicle ſoon falls to the bottom, and another is formed on the ſurface, till almoſt all the earthy matter once diſſolved be ſeparated from the water. Lime-water has a ſharp, urinous taſte, which the calcareous earth had not before calcination.

The ſlaked lime by another calcination is reduced to the ſtate of quicklime, as it was before.

Quicklime combines with the moiſture of the air which it ſeems capable of attracting. By the moiſture thus attracted, the weight of the quicklime is doubled, its bulk is alſo encreaſed, its parts are very much divided, and it is reduced to an exceeding fine powder. In this ſtate it is called *lime ſlaked in the air*.

Lime ſlaked in the air may be reduced, by another calcination, to its former ſtate of quicklime, in the ſame manner as lime ſlaked by water.

Quicklime is capable of uniting with certain ſubſtances, (as, for inſtance, with ſulphur, with which it forms an *earthy liver of ſulphur*) to which the uncalcined calcareous earth could not unite ſo intimately.

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they are colorleſs and tranſparent. When mixed with calxes of iron or of copper, they are black or red. This ſtone does not decay in the air, as ſome other ſiliceous ſtones do. According to Cronſtedt, it always forms hexagonal priſms, pointed at one or both ends, when there has been no interruption to its cryſtallization; and this cryſtallized quartz is rock-cryſtal, which, like the uncryſtallized quartz, is colorleſs or colored, tranſparent or opake. *See* CRYSTAL.

Wallerius ſays, that every quartz is fuſible by fire: but probably the quartz colored by metallic calxes are only fuſible; for Mr. D'Arcet found that the tranſparent and ſemi-tranſparent quartz, and alſo the opake white quartz, were rendered friable, but were not fuſed by a very violent and long continued fire; and that by the ſame fire the form and tranſparency of rock-cryſtals were not altered. *Memoir ſur l'Action d'un Feu Violent, Egal, & Continué, &c. Mem. de l'Acad. des Sc.* 1766.

Beccher and Hiærne ſay, that from quartz a ſmall quantity of alkali may be obtained by diſtillation or by frequent extinction of the heated ſtone in water. A ſimilar alkaline matter is ſaid to be obtainable by diſtillation from flints.

An important queſtion deſerves to be examined, concerning the nature of the volatile ſubſtance of which calcareous ſtones are deprived by fire, and whether the ſeparation of this volatile matter is the cauſe of the phenomena produced by quicklime.

As the properties of quicklime reſemble much thoſe of ſaline ſubſtances, and as even a kind of ſaline matter is obtained from it, moſt chemiſts have believed, that all calcareous ſtones contain more or leſs of ſome ſalt; which being mixed with an earthy matter, cannot ſhew its properties till it has been partly unfolded and diſengaged by the action of fire. Their opinion is grounded on ſome ſaline matter obtained from calcareous ſtones by diſtillation with a violent fire, or from quicklime after its calcination.

Van Helmont, and after him Daniel Ludovicus, pretend to have made an experiment from which they have inferred a peculiar opinion. Theſe chemiſts, having expoſed lime-ſtone to a violent fire in a retort, obtained only a pure water; and they affirm, that the remaining ſtone was not by this operation converted into quicklime. This experiment, together with ſome marks which may be perceived of inflammable matter being contained in lime-ſtone, has induced them to believe, that this inflammable matter is ſo intimately united with the ſaline part of the lime-ſtone, that this cannot exert its properties; and that this matter being, like coals, incapable of combuſtion in cloſe veſſels, it cannot diſengage the ſaline part, that is, quicklime cannot be made, but by calcination in open fire.

Mr. Macquer has repeated this experiment, as may be ſeen in his Memoir upon Quicklime, (Memoirs of the Academy of Sciences, 1747) and found it to be only true in part.

This chemiſt, having expoſed lime-ſtones in a retort to a violent fire continued during ſix hours, obtained a purely aqueous liquor, which ſhewed no ſaline property, and obſerved that the remaining ſtone, though not entirely converted into quicklime, had nevertheleſs acquired all the properties of quicklime in a great degree. The calcination was therefore found to ſucceed in cloſe veſſels without the combuſtion of any inflammable matter contained in the ſtone. *See* CALCINATION.

We are certain therefore, that the experiment of Van Helmont and of Ludovicus proves nothing in favor of their opinion

Stahl believes, with more probability, that all the properties of quicklime proceed merely from ſuch a diviſion and disjunction of the integrant parts of the calcinable earth, by means of the calcination, that they are rendered capable of uniting with the particles of water. He believes that this union is already begun in lime-ſtone; that the fire, during the calcination, does only ſeparate the principles of this compound body, that is, expels the watery part, which being volatile, is incapable of reſiſting the action of fire, and ſeparates it from the earthy principle, and does not deprive the latter principle of its diſpoſition to unite with the former, but rather encreaſes this diſpoſition by attenuating the earthy matter. This theory explains in a ſatisfactory manner all the phenomena of quicklime.

All the properties of calcareous ſtones by which they differ from vitreſcible ſtones, that is to ſay, their inferior degrees of hardneſs and of weight, and the loſs of matter which they ſuſtain by violent fire [*See* Earth (Calcareous), *and* Earth (Vitrifiable)] ſhew, that they contain a principle leſs hard, leſs weighty, and leſs fixed than pure earth: but theſe are preciſely the eſſential properties which conſtitute the difference betwixt earth and water.

In fact, the experiments of Van Helmont, Ludovicus, and of Mr. Macquer ſhew, that water is the principle ſeparated from lime-ſtone during its calcination.

The difficulty with which fire expels all the watery part of lime-ſtone ſhews, that in this ſtone there is at leaſt ſome degree of the union of compoſition, and a true adheſion betwixt the integrant parts of water and thoſe of earth, and alſo gives an inſtance of the great degree of fire which water is capable of ſuſtaining when it is retained by means of an union contracted with a fixed matter. The degree of heat ſuſtained by water on this occaſion muſt neceſſarily enable the water to ſeparate more and more the integrant parts of the earthy matter, and to break their aggregation (in the Digeſtor of Papin), and to give it conſequently a greater diſpoſition to re-unite with water.

This being eſtabliſhed, if we add to quicklime the watery principle which the violence of the fire has expelled, the earthy particles having acquired by calcination a ſtrong diſpoſition to unite with water, theſe two ſubſtances will accordingly unite together with great activity; and as the primary molecules of the two uniting ſubſtances are very hard, the friction occaſioned by their motion during their union muſt produce a conſiderable heat.

This new union contracted by the parts of quicklime with water is much more perfect and more intimate than the union of the conſtituent parts of the lime-ſtone before calcination. As water and earth are the two elements of ſaline ſubſtances (*ſee* Salt), a new, at leaſt, a beginning combination muſt be formed by the extinction of quicklime. In conſequence of this combination, a taſte is given to lime-water, and *cream of lime* is produced, which is ſoluble in water, and ſeparable from thence like a true ſalt, and which muſt be conſidered as a ſaline matter, begun at leaſt, and overcharged with the earthy principle.

It appears certain that the cream of lime is not produced by any ſalts originally mixed with the lime-ſtone, unfolded by the action of fire, and thereby reſtored to their properties and ſolubility in water; for it is not credible that at leaſt the greateſt part of the ſaline matter, which may have been originally mixed with the calcareous earth of lime-ſtones, ſhould not have been already waſhed away by the water to which theſe ſtones have been often expoſed ſince their formation. Beſides, ſuppoſing even that ſome of that ſaline matter ſhould have remained, certainly it would be all waſhed out by one calcination of lime-ſtone, and extinction in water: but we know that quicklime once extinguiſhed, and boiled in any quantity of water, may, by another calcination, be reſtored to the ſtate of quicklime, and to the property of ſolubility in water, and of producing cream of lime as much as before. This phenomenon affords an additional proof, as well as an explanation of the theory of Stahl.

Further, the addition of any ſaline ſubſtances to lime-ſtones, which when calcined yield but a weak quicklime, not only does not render the quicklime more ſtrong and active, but, on the contrary, conſiderably injures its quality.

Theſe facts have been advanced by Mr. Macquer, in his Memoir upon Quicklime, and they ſhow that the properties of calcareous ſtones acquired by calcination are not occaſioned by the preſence of any ſaline matter

The firm adheſion of the water to ſlaked quicklime deſerves attention, and is ſo conſiderable, that the water cannot be entirely ſeparated but by a fire as violent as is required for the firſt calcination of lime-ſtone.

Mr. Duhamel has made a deciſive experiment to ſhew the ſtrength of this adheſion.

Having weighed an ounce of ſlaked quicklime, which had previouſly undergone ſeveral ſtrong calcinations to deprive it of all its water; and obſerving that each ounce of this quicklime, notwithſtanding all theſe calcinations, retained more than three gros and thirty-eight grains of water, he expoſed it again to a very violent fire in a melting furnace, and found that notwithſtanding this further calcination, his ounce of quicklime ſtill retained twenty grains of moiſture. (*Mem. of the Acad. of Sc.* 1747).

This retention of the water united to quicklime during its extinction may be naturally deduced from the adheſion contracted between earth and water; which two ſubſtances really form a new compound conſiſting of two principles, one of which is fixed, and the other is volatile, and in which the volatile part is retained by the fixed part with a ſtrength proportionable to the perfection of the combination of theſe two ſubſtances. Hence we may explain the cauſe of the difficulty of drying ſlaked lime, and of the ſeveral phenomena before related which happened upon expoſure of quicklime to air, and alſo of ſeveral other properties hereafter to be mentioned, all which ſhew the ſaline quality of this ſubſtance. It unites to all acids with the ſame phenomena, as it does before calcination: and the neutral ſalts with earthy baſes, which are formed by the calcareous earth in theſe two ſtates, are very ſimilar to each other. [*See* SALTS (NEUTRAL) *with* EARTHY BASES].

Neverthleſs it ſeems as if the acid of all thoſe ſalts, the baſis of which is quicklime, adheres more ſtrongly than the acid of ſalts, the baſis of which is uncalcined calcareous earth.

Lime-water, which keeps diſſolved the moſt attenuated and moſt ſaline portion of the quicklime, as we have already ſhewn, decompoſes all ſalts with metallic baſes.

Laſtly, quicklime produces alterations upon fixed and volatile alkalis, which cannot be effected by uncalcined calcareous earths.

Fixed alkalis, treated with quicklime, become much more difficult to be dried, more deliqueſcent, more cauſtic, and much more powerfully ſolvent. The ſame alterations are produced by means of quicklime upon volatile alkali, which is thereby rendered much more penetrating, and ſo ſtrongly deliqueſcent that it cannot be then obtained in a concrete ſtate.

Theſe changes are probably produced by the quicklime depriving the alkalis of ſome inflammable matter; and as probably the remaining inflammable matter is a conſtituent part of theſe alkalis, we need not be ſurpriſed that their properties are changed, and that even a decompoſition of their parts ſhould happen upon the quicklime depriving them of this inflammable matter, if the action of the quicklime be ſufficiently applied. And accordingly it happens that by a continued treatment of fixed and volatile alkalis with quicklime, they may be at laſt entirely deſtroyed.

As ſimple calcareous earths do not produce the ſame effects upon alkalis, it follows that quicklime has a more powerful action than thoſe earths upon inflammable matters; and accordingly we find that quicklime unites more intimately than calcareous earths with oils and with ſulphur, forming with this latter ſubſtance a kind of earthy liver of ſulphur, which is ſoluble in water to a certain degree.

This action of quicklime upon alkalis and upon inflammable matters is advantageouſly applied to give activity to the former, and to make them more capable of uniting with oils. Accordingly, the alkali employed in the compoſition of ſoap ought to be always ſharpened by quicklime. *See* SOAP, *and* LEY *of* SOAP-BOILERS.

Fixed alkali ſharpened by quicklime, and reduced to a ſolid conſiſtence by drying, is much more cauſtic than ordinary alkali, and is employed as a cautery. *See* CAUSTIC (COMMON).

The moſt general uſe of quicklime is for building. The property which ſlaked lime has, when mixed with ſand, of forming a *mortar* or cement capable of hardening and acquiring a ſtoney conſiſtence, renders it uſeful for the joining of ſtones of buildings, pavements, &c. This mortar has alſo the advantage of being impenetrable by water, when it has once become ſolid. *See* MORTAR.

Quicklime has medicinal virtues. As an abſorbent earth, it is anti-acid, and is capable of abſorbing any acids which are produced in the ſtomach by a debility of that organ, in the diſeaſes proceeding from a ſpontaneous acid, ſo well deſcribed by Boerhaave. It is ſo much better adapted to thoſe diſeaſes which are always cauſed by inactivity, and by the weakneſs and laxity of the fibres, as it has a tonic quality, which ſimple abſorbent earths have not. *See* EARTHS (ABSORBENT).

As quicklime is alſo drying, and ſomewhat cauſtic, and conſequently cicatriſing, it may contribute to the cure of certain ulcers, eſpecially of the ſoft parts: accordingly ſeveral able phyſicians have preſcribed it ſucceſsfully even for internal ſuppurations, and for the phthiſis of the lungs.

Laſtly, the property which quicklime has of attenuating viſcid matters, and of decompoſing ammoniacal ſalts, has been advantageouſly applied in theſe later times to diſſolve ſtones in the kidneys and bladder. An Engliſh phyſician has made on this ſubject ſome experiments capable of giving hopes of ſucceſs; and M. Roux, Doctor-Regent of the Faculty of Medicine at Paris, who has alſo given other proofs of his chemical abilities, has added conſiderably to theſe experiments; a relation of which, with his own additions, he has publiſhed in French (*l*)

(*l*) The experiments made by Dr. Black on quicklime, and related in the Eſſays phyſical and literary publiſhed at Edinburgh, have enabled that excellent chemiſt to form a new and ſatisfactory theory of the changes produced upon calcareous earths by means of calcination and of thoſe produced upon alkalis by means of quicklime. Theſe we have already mentioned under the articles AIR (FIXABLE), ALKALIS (FIXED *and* VOLATILE), and ſome others. We ſhall nevertheleſs place under one view the principal facts and doctrines concerning quicklime, and for more minute explanations and proofs, we refer to the above-mentioned articles, but eſpecially to the Eſſay itſelf above-quoted.

The beſt method of adminiſtering quicklime, eſpecially for internal uſe,

The claſs of earths and ſtones called by naturaliſts *calcareous*, or chalks and marbles, or thoſe which by calcination are convertible into quicklime, are found by experiments to conſiſt of the following component parts. 1. Of *quicklime*, or pure and uncombined calcareous earth. The quantity of this in a piece of chalk was found by Dr. Black to be equal to $\frac{68}{120}$ of the whole, the remaining $\frac{52}{120}$ parts having been extricated by calcination. 2. Of *fixable air*, which when extricated is found to be permanently elaſtic, and uninflammable. Concerning its properties, *ſee* AIR (FIXABLE). The quantity of this air extricated from a piece of chalk, during its ſolution in an acid, was found by an experiment of Dr Black to be equal to $\frac{2}{5}$ of the whole maſs; and the quantity of air extricated from a piece of marble was found by Mr. Cavendiſh to be $\frac{407}{1000}$ of the whole maſs. As the reſults of the experiments made by theſe two gentlemen ſo nearly concur, we have reaſon to believe that mild calcareous earth is always united and ſaturated with a determinate quantity of fixable air. 3 Of *water.* A certain quantity of water is always extricated from calcareous ſtones during their calcination, and may be collected by diſtillation of theſe ſtones with a retort and receiver. The quantity of water obtained from the diſtillation of oſteocolla, which is a calcareous earth, by Mr. Margraaf, was found to be equal to $\frac{1}{12}$ of the whole maſs. Dr. Black found that chalk loſt by calcination $\frac{52}{120}$ of its weight. If we deduct from that loſs, the $\frac{2}{5}$ which he found by an experiment abovementioned was the quantity of fixable air contained in chalk, the remainder $\frac{4}{120}$ or $\frac{1}{30}$ will be the quantity of water, which is nearly equal to the quantity obtained from oſteocolla. Hence alſo we have reaſon to believe that a certain determinate quantity of water is united with and ſaturates the calcareous earth, when mild, or united with fixable air. But when this earth is ſeparated from its fixable air, it becomes then capable of uniting with a much larger quantity of water, which is alſo probably determinate, as we ſhall find when we conſider the properties of quicklime.

Theſe are the only component parts of the purer chalks, marbles, calcareous ſpars, and ſtalactites; but many of the ſtones and earths which are uſually calcined for making quicklime, as many of the common lime-ſtones and marles, contain, beſides the earth properly called calcareous, various other ſubſtances intermixed, as ſand, or vitrifiable earth, clay, and metallic calxes Some of theſe, as ſand and metallic calxes, if not in too large quantities, are uſeful ingredients in the compoſition of mortar. But we muſt in this article be underſtood to mean calcareous earth unmixed with any other matters. The quantity of calcareous earth in any lime-ſtone may be diſcovered by obſerving how much of that ſtone is ſoluble in marine or nitrous acids, and by adding to the ſolution of the calcareous earth ſome cauſtic volatile alkali, by means of which, if any other earth, as earth of alum, metallic earths, &c. have been diſſolved by the acid, theſe will be precipitated, and the calcareous earth alone will remain diſſolved. By comparing the weight of the ſtone originally employed with the weight of the undiſſolved and precipitated parts, the quantity of calcareous earth in that ſtone may be found: or this quantity may be precipitated from the acid in which it is diſſolved, by adding to the above ſolution of calcareous earth ſome mild fixed or volatile alkali, till no further precipitation is occaſioned.

Native calcareous earths and ſtones may be decompoſed, or reſolved into the above-mentioned component parts, by fire or by acids.

When they are expoſed to fire, the water and the fixable air are volatiliſed, and ſeparated from the earthy part, which remains ſingly, and is then quicklime.

When an acid is applied to native calcareous earths, their fixable air is diſengaged, recovers its elaſticity, and is diſſipated, while the acid remains united with the earth and the water, forming a ſalt with baſis of calcareous earth. *See* SALTS. The earth or quicklime may be ſeparated from the acid by means of a fixed alkali, which having a greater diſpoſition to unite with the acid, precipitates the earth. If the alkali employed be cauſtic, or deprived of fixable air, the earth precipitated will be alſo cauſtic, or quicklime. But if the alkali is lime-water, becauſe this water has all the medicinal properties of quicklime,

kali employed be mild, that is, combined with fixable air, this air will unite with the earth; and thus the quicklime will be rendered mild, or reſtored to its original ſtate of native calcareous earth, combined with air.

Quicklime has the following properties. 1. It is entirely ſoluble in water, with which it unites ſo rapidly, as to occaſion conſiderable heat. When expoſed to air, it imbibes moiſture from thence. When united with as much water as is ſufficient to make it a fluid paſte, it is called *ſlaked lime*. Water ſaturated with quicklime is called *lime-water*. According to Brandt, lime-water contains about one part of quicklime to ſeven or eight hundred parts of water. Slaked lime, or lime-water, being expoſed to the atmoſphere, attract from thence particles of fixable air which float in it, by which means the quicklime is rendered mild, unſoluble in water, and therefore appears on the ſurface of the lime-water or of the ſlaked lime where this combination happens, in the ſtate of mild or combined calcareous earth, convertible by a ſecond calcination into quicklime, and is called *cream of lime*.

If the earth diſſolved in lime-water be precipitated from thence by any ſubſtance containing fixable air, as by mild alkalis, or magneſia, it will unite with this air, become mild, and reſume its former weight and properties which it poſſeſſed before calcination. But if it be precipitated from the water by means of ſome ſubſtance which does not contain fixable air, but which is more ſtrongly diſpoſed than the earth to unite with the water, for inſtance, ſpirit of wine, the earth thus precipitated will be in the ſtate of quicklime, that is, cauſtic, and ſoluble in water.

2. Quicklime unites with acids without effervescence, which is nothing elſe than an extrication of the fixable air, of which quicklime has been already deprived. It nevertheleſs ſaturates as much acid as it would have done if it had not been calcined.

3. Quicklime is more powerfully diſpoſed to unite with fixable air than fixed or volatile alkalis, or magneſia. Hence, when treated with theſe ſubſtances, it takes from them their fixable air, and is itſelf rendered mild, and reſtored to its original weight and properties. Thus two drams of chalk, having been by calcination reduced to one dram and eight grains of quicklime, were thrown into a filtrated ſolution of an ounce of mild fixed alkali in two ounces of water, and digeſted during ſome time; by which the calcareous earth became mild, and weighed one dram and fifty-eight grains. By means of magneſia, the calcareous earth may be precipitated from lime-water, and this earth is found to be mild, and to have deprived the magneſia of its fixable air. By depriving alkalis of their fixable air, quicklime renders them more cauſtic and ſolvent, for the ſame reaſon that itſelf is by this privation of air rendered more cauſtic and powerfully ſolvent. This increaſe of cauſticity and diſſolving power is conſiſtent with a general rule, namely, that the more ſimple or leſs compounded any body is, that is, the leſs its general tendency to union is ſatisfied, the more diſpoſed it is to unite with or diſſolve other ſubſtances. *See* AIR (FIXABLE), ALKALIS.

4. Quicklime has a diſpoſition to unite with ſulphur, with which it forms a hepar of ſulphur, ſimilar to that made by ſulphur united with an alkali, and, like this, ſoluble in water. It is alſo diſpoſed to unite with oils and with animal and vegetable matters, by which means it poſſeſſes a cauſtic and corroſive property.

5. Quicklime mixed with ſand forms a maſs which hardens, and is uſed as a cement or mortar. The hardening ſeems to be occaſioned by a cryſtallization of the calcareous earth when the ſuperfluous water is exhaled, and is ſimilar to the hardening of calcined gypſum or plaſter of Paris, when mixed haſtily with a ſufficient quantity of water to effect the cryſtallization of its minute particles. The uſe of the ſand added to quicklime in making mortar is to prevent thoſe cracks which would be formed by the drying of the calcareous earth, and by which its coheſion would be greatly diminiſhed. This effect the ſand produces, by diminiſhing

and becauſe the parts of the quicklime diſſolved in it are exceedingly fine, and conſequently perfectly diſtributed. *See* WATER (LIME).

niſhing the proportion which the contraction of dimenſions, occaſioned by drying, bears to the dimenſions of the whole maſs, which is to be thus expoſed to contraction and drying; the ſand being itſelf incapable of ſuffering any contraction.

R.

DLXXVII. RAIN. *See* WATER.

DLXXVIII. REALGAR, *or* REALGAL. Theſe names have been given to compoſitions of ſulphur and arſenic. Theſe two ſubſtances are capable of uniting together, eſpecially when they are reduced to vapors, and ſublimed together. The whiteneſs of cryſtalline arſenic is always altered by union with ſulphur; and the new compound becomes yellow, inclining more or leſs to an orange, or even to a red color, according to the quantity of ſulphur united with the arſenic. When the ſulphur is only a tenth part of the whole mixture, the ſublimate is yellow. It is then called *yellow realgar*, or *yellow arſenic*, and in commerce *orpiment*.

When the ſulphur is a fifth part of the combination, the ſublimate is red. It is then called *red realgar*, *ſandarach*, *red arſenic*, &c. To few ſubſtances have ſo many names been given as to arſenic and its compounds, as may be ſeen in ſeveral authors of mineralogy, and particularly in Henckel's Pyritologia.

As ſulphur fixes arſenic a little, the red realgar may be melted with a gentle heat; and when it has become ſolid, it is tranſparent, and then is called *ruby of ſulphur*, or *arſenical ruby*.

Theſe combinations of arſenic and ſulphur are not generally made in laboratories, becauſe they do not ſucceed well, as Henckel remarks, when pure arſenic and pure ſulphur are ſublimed together. They are prepared in countries abounding in ores, which are ſmelted by mixing together ſome that contain arſenic, as the *white pyrites*, with others that contain ſulphur, like the *ſulphureous pyrites*, or *ſulphureous ſcorias*, the quantity of each of which is proportioned as experience taught.

Theſe artificial combinations of ſulphur and arſenic ought to be diſtinguiſhed from thoſe which nature offers to us ready made, as orpiment. They have been very improperly confounded by ſeveral authors. Both the natural and artificial compounds are poiſons, although Hoffman ſays that the natural orpiment is not poiſonous. The yellow and red artificial arſenics are probably more pernicious. The principal uſe of theſe ſubſtances is for painting.

When arſenic and ſulphur are thus well combined together by ſublimation, they cannot be ſeparated without ſome intermediate ſubſtance, becauſe they are volatile: but this ſeparation may be effected by means of fixed alkali or mercury. *See* ARSENIC.

DLXXIX. RECEIVER. Receivers are chemical veſſels, which are adapted to the necks or beaks of retorts, alembics, and other diſtillatory veſſels, to collect, receive, and contain the products of diſtillations.

Receivers ought to be made of glaſs, not only becauſe this matter reſiſts the action of the ſtrongeſt and moſt corroſive ſubſtances, but alſo becauſe being tranſparent it allows the operator to ſee through it, and to judge by the frequency of the drops, if the diſtillation be too faſt or too ſlow, and alſo if the quantity and nature of the ſubſtances which come over be ſuch as is required.

Almoſt all receivers are kinds of bottles of different ſizes, of a ſpherical form, the necks of which are cut ſhort, and each of which is pierced with a ſmall hole in its lateral or upper part, to give vent to the air or vapors which are too expanſive. Receivers of this form are called *balloons.* *See* BALLOON.

Some receivers are matraſſes with long necks. Theſe are generally adapted to the beaks of glaſs alembics. This long neck ſerves to keep the belly of the receiver, where the liquor is collected, at a proper diſtance from the fire.

Receivers have different forms for particular operations. Such are thoſe which have two or three beaks, either to be adapted to other receivers, or to admit at the ſame time the necks of ſeveral diſtillatory veſſels, when the intention of the operator is that the vapors of different ſubſtances ſhould meet in the ſame receiver. Such alſo are *receivers for eſſential oils*, which are very convenient for the diſtillation of theſe oils. To obtain the eſſential oil of aromatic plants, theſe plants muſt be diſtilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, riſes in diſtillation, carrying with it the eſſential oil, which alſo has the property of riſing with this degree of heat. *See* OILS.

As a large quantity of water muſt be employed, that the plant may always be kept immerſed in the alembic, and conſequently as a good deal of it riſes in proportion to the oil, any receiver of ordinary ſize would be ſoon filled with water, with a little oil floating upon its ſurface; and would require to be frequently changed, which would be very troubleſome, and would occaſion a loſs of part of the oil.

Theſe inconveniencies are avoided by uſing receivers contrived purpoſely for ſuch diſtillations. They are ſo made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glaſs cucurbits, which contract as they riſe higher; ſo that their neck or upper opening is but nearly of a convenient ſize to receive the beak of the *worm.* Theſe receivers have another opening about the middle of the ſwelling or belly; and to this opening is joined a glaſs tube, which bends and riſes vertically along the outer part of the receiver, ſo as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the ſide oppoſite to the body of the receiver, to pour into another veſſel the liquor which riſes there. It forms the figure of S.

When this receiver is to be uſed, it is to be placed vertically under the beak of the worm. During the diſtillation, the liquor riſes to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it muſt begin to flow from the mouth of this tube into another veſſel placed on purpoſe to receive it: but as eſſential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which diſcharges itſelf through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with ſuch a receiver, we may diſtill without the trouble of changing the veſſels; which is certainly very advantageous.

DLXXX. RECTIFICATION. By rectification is meant the exact purification of certain ſubſtances, by means of *diſtillation* or of *ſublimation.*

This operation is neceſſary to diſengage many chemical products or agents from a mixture of extraneous matters which deſtroy their purity. Thus, for inſtance, vitriolic acid, when firſt obtained from *vitriol* or from *ſulphur*, is always charged with a conſiderable quantity either of inflammable matter, which renders it black and ſulphureous; or of ſuperabundant water, which weakens it. It is ſeparated from both theſe matters by a ſecond diſtillation, in which they being more volatile than the acid, are carried off; which ſecond diſtillation is called *concentration* or *rectification of vitriolic acid. See* CONCENTRATION *of* VITRIOLIC ACID.

Alſo when animal and vegetable matters are decompoſed by diſtillation, all the portion of oil that is not volatile contained in theſe ſubſtances does not riſe but with a degree of fire ſo ſtrong as to burn a part of them, and to raiſe along with them a conſiderable portion of ſaline ſubſtances, which, being mixed with the oily part, conſiderably alter its purity. To purify theſe oils, which, from their burnt ſmell, are called *empyreumatic*, new diſtillations muſt be applied, in which, by means of a leſs heat, the moſt volatile and pureſt part of theſe oils is ſeparated from the moſt empyreumatic and ſaline parts, which remain at the bottom of the retort: this is called the *rectification of empyreumatic oils. See* OIL (RECTIFIED ANIMAL) *or of* DIPPEL.

The ardent ſpirits obtained by a firſt diſtillation of liquors which have undergone the ſpirituous fermentation, are overcharged with a large quantity of phlegm and light oil, which riſe along with them in this firſt diſtillation. The product of this diſtillation is called *aqua vitæ.* It is an ardent ſpirit very far from the degree of dephlegmation and purity which good ſpirit of wine ought to have to render it fit for chemical operations, and for ſeveral compounds commonly uſed, ſuch as perfumed waters and *liqueurs* for the table. This ſpirit of wine is to be purified, or rather the aqua vitæ is to be changed into ſpirit of wine by new diſtillations, ſlowly conducted with a gentle fire and water-bath, by means of which the moſt volatile part that always riſes firſt with the leaſt heat, and which is the true ſpirit of wine, is ſeparated from the leſs volatile part that remains in the alembic, and which contains the phlegm and oil of wine, by which the ſpirit of wine was rendered impure. The firſt liquor of theſe ſecond diſtillations or rectifications is called *rectified ſpirit of wine. For its properties ſee* SPIRIT (ARDENT).

When only a ſmall quantity of ſpirit of wine is to be rectified, the operation is difficult, eſpecially when we would have it perfectly rectified. The cauſe of this difficulty proceeds from the very ſmall quantity of the firſt liquor obtained in this rectification. Several chemiſts, to obtain a larger quantity or the firſt ſpirit, propoſe to mix with the ſpirit of wine ſome intermediate ſubſtances to abſorb and retain its phlegm and oil, ſuch as dried and calcined ſalts, very dry chalk, &c. Kunckel propoſes to ſeparate more effectually the oil, by adding to the ſpirit a large quantity of water, and by diſtilling this diluted ſpirit with a very gentle heat. This method is indeed very capable of facilitating the ſeparation of the oil of wine from the ſpirit of wine; becauſe this oil certainly adheres to the ſpirit, which is the chief obſtacle to its ſeparation; and becauſe the ſpirit of wine has greater affinity with water than with oil; ſo that when it is diluted with much water, it quits the oil to unite with the water. This expedient of Kunckel is therefore very good to facilitate the ſeparation of ſpirit of wine from the oil which renders it impure; but, on the other hand, when it is practiſed, we are afterwards obliged to deprive the ſpirit of wine of the water with which it was diluted.

All this trouble and inconvenience may be avoided by rectifying at once a large quantity of aqua vitæ. Nothing more is required to obtain at once a conſiderable quantity of pure ſpirit of wine, than to ſet aſide the twelve or fifteen pints firſt drawn over from a large quantity, ſuppoſe from three hundred pints of aqua vitæ, diſtilled with a very gentle fire in a large alembic. As the moſt ſpirituous, leaſt aqueous, and leaſt oily part of it always riſes firſt, theſe twelve or fifteen pints are perfectly rectified ſpirit of wine, eſpecially when the heat has been well conducted. By thus keeping apart portions of the ſpirit obtained at different times, we may have ſpirit of wine of the ſeveral degrees of ſtrength and purity. The weaker ſpirit may, by another diſtillation, be again rectified. Laſtly, the ſpirit of moderate ſtrength may be preſerved, as it is fit for many uſes. This method is followed by Mr. Beaumé in the rectification of ſpirit of wine, and is certainly the moſt convenient and the beſt.

The volatile ſalts obtained in the decompoſition of certain oily ſubſtances, as volatile alkalis, from decompoſed animal matters, are always very impure, and ſpoiled by much fetid empyreumatic oil, which riſes along with them. They are purified and diſengaged by ſubjecting them to new diſtillations or ſublimations with a well conducted heat. The ſame obſervation is applicable to butter of antimony, artificial cinnabar, phoſphorus, and of many other chemical products, which are always impure when obtained by a firſt operation, and muſt therefore be purified by a ſecond diſtillation or ſublimation. All theſe ſecond operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We ſhall not therefore enter into the details of them; but we ſhall obſerve only, that all rectifications are founded upon the ſame principle. They all conſiſt in ſeparating ſubſtances more volatile from ſubſtances leſs volatile; and the general method of effecting this is to apply only the degree of heat which is neceſſary to cauſe this ſeparation. *See* DISTILLATION *and* SUBLIMATION.

DLXXXI. RED. (m)

DLXXXII. REDUCTION *or* REVIVIFICATION.

This word, in its moſt extenſive ſenſe, is applicable to all operations by which any ſubſtance is reſtored to its natural ſtate, or which is conſidered as ſuch: but cuſtom confines it to operations by which metals are reſtored to their metallic ſtate after they have been deprived of this ſtate, either by the loſs of their phlogiſton, as metallic calxes, or by the union of ſome heterogeneous matters which diſguiſe them, as *fulminating gold*, *luna cornea*, *cinnabar*, and other compounds of the ſame kind. Theſe *reductions* are alſo called *revivifications*. We ſhall treat of both theſe kinds of reduction.

The reduction of metallic calxes regards only imperfect metals; becauſe theſe alone are ſuſceptible of loſing their metallic properties by the loſs of phlogiſton. They may be deprived of this principle by the action of air or of water, which changes them to *ruſt*; or by the action of acids, particularly of the nitrous and vitriolic; or, laſtly, by ordinary calcination, that is, by the combuſtion of their phlogiſton in an open fire.

Metals deprived of their phlogiſton by any of theſe cauſes have not their peculiar color, luſtre, ductility, nor even conſiſtence and gravity. They have the appearance of earths, the parts of which are unconnected, unleſs they have ſuſtained a fire violent enough to fuſe them; and then they become brittle vitrified matters.

But theſe metallic earths, calxes, or glaſſes, are capable of being again combined with the inflammable principle, and of recovering all the metallic properties. For this purpoſe their calcination or dephlogiſtication muſt not have been too compleat, and the phlogiſton muſt be applied in a ſtate favorable for combination. Theſe calxes, particularly thoſe of metals which cannot be radically calcined, as lead, biſmuth, iron, and copper, may recover their phlogiſton, and may be reduced even without fire or fuſion, merely by the contact of phlogiſtic vapors; for inſtance, by the vapor of liver of ſulphur; or they may be reduced in the humid way, that is, when they are precipitated by ſome ſubſtance capable of applying phlogiſton to them.

But we muſt obſerve, that metals reduced by either of theſe methods are only ſuperficially ſo, when the metallic maſſes are conſiderably large; and that when the metals thus reduced conſiſt of fine molecules, theſe molecules, although well reduced and provided with all their metallic properties, remain always disjoined and ſeparated from each other; either becauſe they are not ſmall enough, or becauſe they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by theſe methods: but the operations of our laboratories are very different from thoſe of nature. Accordingly, in practical chemiſtry a much more expeditious method for making theſe reductions is employed; which is fuſion.

The reduction of metallic calxes by fuſion is generally a quick and eaſy operation. It, however, requires certain attentions and management; which are: 1. To mix accurately the metallic calx to be reduced with the proper quantity of the matter which is to give it phlogiſton. 2. To add to the mixture ſome ſaline or vitreous matter capable of facilitating the fuſion and ſeparation of the reduced metal from the ſcoria. 3. To prevent any communication with external air, that the phlogiſton may not be burnt and conſumed. 4. To keep the fire low at firſt, that the too great ſwelling, which is generally occaſioned by the re-action of the inflammable principle with metallic earths, may be prevented; and to raiſe the fire towards the end, ſo that not only the metal, but alſo the ſupernatant ſcoria, may be perfectly fuſed; whereas if the ſcoria was not well fuſed and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

(m) RED. Concerning the ſubſtances which give a red color to ſtuffs, glaſs, enamels, &c. *ſee the articles* FLOWERS, FRUITS, COCHINEAL, MADDER, KERMES, LAC, DYING, MANGANESE, POWDER *of* CASSIUS, ENAMEL.

The operations muſt be very exactly performed, eſpecially in eſſays of ores, in which the preciſe quantity of metal is required to be known. Theſe eſſays of ores are in ſome meaſure the only reductions of this kind which are performed in practical chemiſtry, as the reduction of pure metallic calxes differs only from the former in requiring a leſs quantity of flux; becauſe theſe calxes do not, as the ores do, contain a difficultly fuſible earthy or ſtony matter: we therefore refer to the article ESSAY *of* ORES. Here we ſhall only obſerve, that when we treat very volatile ſemi-metals, as zinc and arſenic, the reduction ought to be made in veſſels perfectly cloſe; for inſtance, in an earthen retort. We find after the reduction theſe metallic matters ſublimed in the vault or neck of the retort.

The reduction of metals which do not loſe their inflammable principle, as gold, ſilver, and mercury, is of another kind. As theſe metals can be only diſguiſed by the union they have contracted with ſome heterogeneous ſubſtance, they are to be reduced, not by reſtoring phlogiſton, but by ſome intermediate ſubſtance capable of ſeparating from them the matter which is united with them. Theſe intermediate ſubſtances muſt therefore differ according to the matter united with the metal.

For inſtance, fulminating gold may be reduced by fuſing it with ſulphur, or with fixed alkali; becauſe either of theſe ſubſtances is capable of decompoſing the nitrous ammoniacal ſalt which gives the fulminating property to gold. *See* GOLD (FULMINATING). Luna cornea alſo is reduced by fuſing it with a large quantity, as, for inſtance, with twice its weight of fixed alkali; becauſe in this reduction the marine acid united with the ſilver is to be ſeparated, and the fixed alkali is capable of effecting that ſeparation. The reduction of luna cornea is attended with difficulties, becauſe this compound is ſemi-volatile and very penetrating; ſo that when it is expoſed to fire, ſome part of it is always loſt, whether it exhales in vapors or penetrates the crucible. Several chemiſts recommend the reduction of luna cornea by fuſing it with fat matters, which, from experience, I know to be a very bad method; for the marine acid has a ſtrong affinity with ſilver, and has no diſpoſition to unite with phlogiſton, or even with ſubſtances which contain much of it.

Luna cornea may alſo be well reduced by precipitation, and by treating it with other metals which have more affinity than ſilver with marine acid, ſuch as tin, iron, regulus of antimony. Mr. Margraaf gives, in his *Opuſcules Chemiques*, a proceſs which deſerves a place here; becauſe, according to this excellent chemiſt,

miſt, a very pure ſilver is obtained, and without any loſs. It conſiſts in mixing well, in a glaſs mortar, luna cornea with ſome concrete volatile alkali, in the proportion of about five gros of luna cornea with an ounce and a half of volatile ſalt, to which a little water is to be added to give to the mixture a ſoft conſiſtence. This mixture ſwells with a kind of efferveſcence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a gros of volatile alkali is to be added, to replace that which is diſſipated; and afterwards a larger quantity of water. Upon the addition of this water appears a fine amalgam of ſilver, which is to be waſhed ſeveral times, till the water comes off clear. This amalgam is then to be diſtilled, by which the mercury is expelled, and all the ſilver which was contained in the luna cornea remains pure, excepting about four grains which have been waſhed away.

The mercury of cinnabar is to be reduced or ſeparated from ſulphur, by mixing with the cinnabar any ſubſtance which has greater affinity with the ſulphur than mercury has, ſuch as fixed alkalis, abſorbent earths, iron, copper, lead, ſilver, or regulus of antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole diſtilled together, by which the mercury will be raiſed and collected at the bottom of the receiver under ſome water placed there to facilitate its condenſation. The ſulphur of the cinnabar remains in the retort united with the intermediate ſubſtance employed for the ſeparation. This mercury is called *mercury revived from cinnabar*. It is juſtly conſidered as very pure.

DLXXXIII. REFINING. Refining is a term uſed in chemiſtry and ſeveral arts to ſignify the purification of ſome ſubſtance, particularly of metals, as gold, ſilver, copper, iron, &c.

We ſhall here treat only of the refining of gold and ſilver; and for the refining of other ſubſtances we refer to their ſeveral articles.

Gold and ſilver may be refined by ſeveral methods, which are all founded on the eſſential properties of theſe metals, and acquire different names according to their kinds. Thus, for inſtance, gold, having the property which no other metal, not even ſilver, has, of reſiſting the action of ſulphur, of antimony, of nitrous acid, of marine acid, may be purified by theſe agents from all other metallic ſubſtances, and conſequently may be refined. Theſe operations are diſtinguiſhed by proper names, as *purification of gold by antimony*, *parting*, *concentrated parting*, *dry parting*. In a ſimilar manner, as ſilver has the property, which the imperfect metals have not, of reſiſting the action of nitre, it may be refined by this ſalt: but the term *refining* is chiefly applied to the purification of gold and ſilver by lead in the cupel. We ſhall therefore treat only of this latter manner of purifying theſe metals, referring for the others to the words PURIFICATION *and* PARTING. *See theſe words.*

The refining of gold and ſilver by lead in the cupel is made by the deſtruction, vitrification, and ſcorification of all the extraneous and deſtructible metallic ſubſtances with which they are allayed.

As none but the perfect metals can reſiſt the combined action of air and fire, without burning, that is, without loſing their inflammable principle, their metallic properties and forms, and without being changed into earthy or vitreous matters, incapable of remaining any longer united with ſubſtances in a metallic ſtate, there is then a poſſibility of purifying gold and ſilver from all allay of imperfect metals merely by the action of fire and air; only by keeping them fuſed till all the allay be deſtroyed: but this purification would be very expenſive, from the great conſumption of fuel, and would be exceedingly tedious. I have ſeen ſilver allayed with copper, expoſed longer than ſixty hours to a glaſs-houſe fire without being perfectly refined: the reaſon of which is, that when a ſmall quantity only of imperfect metal remains united with gold or ſilver, it is covered and protected from the action of the air which is neceſſary for the combuſtion of the imperfect metals, as of all combuſtible matters. *See* CALCINATION.

This refining of gold and ſilver merely by the action of fire, which was the only method anciently known, was very long, difficult, expenſive, and imperfect: but a much ſhorter and more advantageous method has been diſcovered. This method conſiſts in adding to the allayed gold and ſilver a certain quantity of lead, and in expoſing afterwards this mixture to the action of the fire. Lead is one of the metals which loſes moſt quickly and eaſily enough of its inflammable principle to ceaſe to be in a metallic ſtate; but, at the ſame time, this metal has the remarkable property of retaining, notwithſtanding the action of the fire, enough of this ſame inflammable principle to be very eaſily melted into a vitrified and powerfully vitrifying matter, called *litharge*. *See* LITHARGE.

The lead then which is to be added to the gold and ſilver to be refined, or which happens naturally to be mixed with theſe metals, produces in their refining the following advantages: 1. By encreaſing the proportion of imperfect metals, it prevents them from being ſo well covered and protected by the perfect metals. 2. By uniting with theſe imperfect metals, it communicates to them a property it has of loſing very eaſily a great part of its inflammable principle. 3. Laſtly, by its vitrifying and fuſing property which it exerciſes with all its force upon the calcined and naturally refractory parts of the other metals, it facilitates and accelerates the fuſion, the ſcorification, and the ſeparation of theſe metals. Theſe are the advantages procured by lead in the refining of gold and ſilver.

The lead which in this operation is ſcorified, and ſcorifies along with it the imperfect metals, ſeparates from the metallic maſs, with which it is then incapable of remaining united. It floats upon the ſurface of the melted maſs; becauſe by loſing part of its phlogiſton, it loſes alſo part of its ſpecific gravity, and laſtly it vitrifies.

Theſe vitrified and melted matters accumulating more and more upon the ſurface of the metal while the operation advances, would conſequently protect this ſurface from the contact of air which is abſolutely neceſſary for the ſcorification of the reſt, and would thus ſtop the progreſs of the operation, which could never be finiſhed, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the veſſel in which the melted matter is contained; and which being porous, abſorbs and imbibes the ſcorified matter as faſt as it is formed, or by a channel cut in the edge of the veſſel through which the matter flows out.

The veſſel in which the refining is performed is flat and ſhallow, that the matter which it contains preſents to the air the greateſt ſurface poſſible. This form reſembles that of a cup, and hence it has been called *cupel*. *See* PLATE I. *Fig.* 10. The furnace ought to be vaulted, that the heat may be applied upon the ſurface of the metal during the whole time of the operation. Upon this ſurface a cruſt or dark-colored pellicle is continually forming. In the inſtant when all the imperfect metal is deſtroyed, and conſequently the ſcorification ceaſes, the ſurface of the perfect metals is ſeen, and appears clean and brilliant. This forms a kind of *fulguration* or *coruſcation*. By this mark the metal is known to be refined. If the operation be ſo conducted that the metal ſuſtains only the preciſe degree of heat neceſſary to keep it fuſed before it be perfectly refined, we may obſerve that it fixes or becomes ſolid all at once in the very inſtant of the coruſcation; becauſe a greater heat is required to keep ſilver or gold in fuſion, when they are pure, than when allayed with lead.

The operation of refining may be performed in ſmall or in large quantities, upon the ſame principles, but only with ſome differences in the management. As the refining of ſmall quantities of perfect metals is performed in the ſame manner as theſe metals are eſſayed, the eſſay being only a very accurate refining, we refer to the article Essay *of the* Value *of* Silver.

Large quantities of ſilver are thus purified, after the operations by which that metal is obtained from its ores. This ſilver, being always much allayed, is to be mixed with a ſufficient quantity of lead to compleat its purification, unleſs lead has been added in its firſt fuſion from the ore, or unleſs it has been extracted from an ore which alſo contains lead; in which latter caſe, it is allayed naturally with a ſufficient quantity, or more than ſufficient, for the refining of it. *See* Ores *of* Silver. One of the ores of this kind, which is treated in the beſt manner, is the ore of Ramelſberg in Saxony. The ſeveral operations which are practiſed in this country, abounding in mines and excellent metallurgiſts, have been exactly deſcribed by Schlutter. We ſhall here give a ſuccinct extract of the method of purifying large quantities of ſilver, from Hellot's tranſlation of Schlutter's work.

The workmen give the name of *the work* to the lead containing ſilver, obtained by ſmelting the ore of Ramelſberg. The firſt operation, called *fining*, upon this maſs of lead and ſilver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the ſurface of the metal. *See a plan and ſection of this furnace*, Plate II. *Fig.* 16 *and* 17. This furnace is ſo conſtructed, that the flame of the wood, which is put in the fire-place through a hole called the fire-hole, is directed ſo as to circulate over the *work* within the furnace. The flame is thus directed by a current of air which is introduced through the aſh-hole, and paſſes out at an opening made at the ſide of the place where the work is. The wood is conſiderably ſaved by this direction of the flame. In the furnace a large cupel or teſt is to be diſpoſed. This teſt is to be made with aſhes of beech wood well lixiviated, that the ſalt may be waſhed from them. *See* Cupel. In ſome founderies different matters are added to the aſhes, as ſand, lime, clay, calcined ſpar or gypſum. We may obſerve, concerning theſe additions, that they would be very injurious, and would make the teſt melt, if a ſtrong heat were applied; but the heat requiſite for fining is only moderate. *See at the word* Essay *the inconveniences and marks of too ſtrong a heat.*

When the teſt is well prepared and dried, all the *work* is to be put into it at once, which is generally ſixty-four quintals: the fire is then to be made in the fire-place with faggots; but the fuſion is not to be too much haſtened, firſt, that the teſt may have time to dry thoroughly, which is very eſſential; for if any moiſture remained when the metal is melted, an exploſion might happen: ſecondly, becauſe the *work* of the ore at Ramelſberg, and of moſt others, is rendered impure by the mixture of many metallic matters, which ought to be ſeparated, otherwiſe they would ſpoil the litharge, and give a bad quality to the lead afterwards obtained from that litharge. Theſe extraneous matters found in the *work* of Ramelſberg are, copper, iron, and matt. As theſe ſubſtances are hard and refractory, they do not melt ſo ſoon as the *work*, if the heat be moderate; and beſides, as they are ſpecifically lighter than the mixture of lead and ſilver, they float upon the ſurface of theſe two metals when melted, in form of a pellicle or ſkin, which is to be taken off. Theſe impurities are called the ſcum or firſt droſs. The remainder forms alſo a ſcum, which appears when the work has received more heat, but before the litharge has begun to form. This is a ſcoria which is to be carefully taken off, and is called the ſecond droſs.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the ſurface of the metals, by means of iron plates placed for that purpoſe before the blaſt-hole, and which are called papillions. This air is not intended to encreaſe the fire, but to facilitate the combuſtion of the lead, and to puſh the litharge to a channel in the oppoſite ſide of the teſt. This channel is called *the way of the litharge*, becauſe through this paſſage all the litharge, which is not imbibed by the teſt, flows out of the furnace. The litharge which is found in the middle of the large lumps is friable, and crumbles into powder like ſand. It is put in caſks, each of which contains five quintals of it, and is ſold by the name of *ſaleable litharge*. It is uſed for various purpoſes, and particularly for glazing of earthen ware. The other part which remains is called *cold litharge*. It is remelted and reduced to lead. This fuſion is called *cold fuſion*, and the lead produced from it, called *cold lead*, is good and ſaleable, when the work has been well purified from the extraneous matters mentioned above. The teſts impregnated with litharge are added to the ſame kind of ore when ſmelted; becauſe they contain not only much litharge, which may be reduced to lead, but alſo ſome ſilver, in all refinings, whether in great or in ſmall, as Mr. Tillet obſerves.

When about two-thirds of the work are converted into litharge, no more of it is formed: the ſilver is then covered with a ſort of white ſkin, which the refiners call *lightening*; and they call the metal *lightened ſilver* or *fined ſilver*. The ſilver thus fined is not pure: every mark of it contains about four gros of lead: it is given to workmen, who compleat the purification of it in the ordinary method, that is, by a ſecond cupellation with a hotter fire; which latter purification is called *refining*, and the perſons who perform it are called *refiners*. The workmen employed in this firſt operation or fining give improperly the name *lightening* to the white ſkin formed on the ſurface of the ſilver, when brought only to a certain degree of fineneſs; for we know that in eſſays the lightening or coruſcation above-mentioned does not appear but when the ſilver is perfectly fine, or, at leaſt, as fine as it can be made by cupellation.

A fining of ſixty-four quintals of work of Ramelſberg yields about eight or ten marks of fine ſilver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of ſaleable litharge, from twenty-two to twenty-three of

cold

cold litharge, from twenty to twenty-two quintals of teſts, and ſix or ſeven quintals of droſs. The operation laſts from ſixteen to eighteen hours.

If the ſilver before theſe operations was allayed with gold, it retains it ſtill after the fining and refining. The gold, if the quantity be conſiderable enough, may be ſeparated by parting. The operations for the purification of gold by cupellation are perfectly the ſame as thoſe of ſilver. If the gold to be fined contains ſilver, this ſilver remains with it after the operation; becauſe both theſe metals reſiſt the action of lead. The ſilver may afterwards be ſeparated by parting.

DLXXXIV. REFRACTORY. This word is applied to unfuſible ſubſtances, or thoſe which cannot be melted in a violent fire.

DLXXXV. REFRIGERATORY. A refrigeratory is a copper veſſel ſoldered round the capital of the alembic. Its uſe is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpoſe. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapors of the liquor which riſe in diſtillation may be condenſed more eaſily and more quickly. Theſe refrigeratories were much uſed formerly, and all alembics were furniſhed with them: but modern diſtillers find that this veſſel is not attended with the advantages formerly believed; for the diſtillation cannot ſucceed unleſs the capital of the alembic be as hot, or almoſt as hot, as the cucurbit. Mr. Beaumé obſerved, that when the capital was cooled by very cold water, the diſtillation is ſoon ſtopped, and does not again begin till the capital is conſideraly heated.

The refrigeratory has for theſe reaſons been much neglected, and a *worm* ſubſtituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this reſpect, that it is adapted to the noſe of the alembic, inſtead of ſurrounding the capital. *See* ALEMBIC, DISTILLATION, *and* WORM. *See alſo* PLATE I. *Fig.* 8.

DLXXXVI. REGISTER. Regiſters are openings in different parts of furnaces, which are to be ſhut occaſionally with ſtoppers of burnt clay. By means of regiſters we may govern the fire as we pleaſe; for by opening or ſhutting them properly we may not only encreaſe or diminiſh the activity of the fire, but alſo we may apply its action more to one part of the furnace than another, by giving direction to the current of air which paſſes thro' it. Notwithſtanding the utility of regiſters, they are much neglected. Many chemiſts have diſuſed regiſters, probably becauſe they did not find the advantages from them which they expected. The reaſon of this is, that regiſters have hitherto been ill made Their principal fault is, that they are generally too ſmall. A regiſter cannot have its proper effect unleſs it have an opening of two, three, or four inches, for a furnace, the internal diameter of which is a foot: but we frequently ſee furnaces of eighteen or twenty inches diameter, with regiſters, the openings of which are ſcarcely eight or ten lines. Beſides, all thoſe who uſe furnaces are far from underſtanding their conſtruction. *See* FURNACE.

DLXXXVII REGULUS. The name *regulus* is given by chemiſts to metallic matters when ſeparated from other ſubſtances by fuſion. This name was introduced by alchemiſts, who expecting always to find gold in the metal collected at the bottom of their crucibles after fuſion, called this metal thus collected, *regulus*, as containing gold, the king of metals. But although, ſince the cultivation of philoſophical chemiſtry, theſe metallic maſſes compoſed of ſeveral metals mixed together are frequently called by this name, yet it is more particularly applied to certain ſemi-metals which have no proper name, ſuch as the *regulus of antimony*, *regulus of arſenic*, and *regulus of cobalt*.

DLXXXVIII. REGULUS *of* ANTIMONY. Regulus of antimony is the ſemi-metallic ſubſtance contained in mineral antimony, after it has been ſeparated by proper operations from the ſulphur which mineraliſes it.

This ſemi-metal, when very pure and well-fuſed, is of a white ſhining color, and is compoſed of laminæ applied to each other. It is one of the metallic matters which moſt eaſily takes the regular arrangement of parts which is proper to it. When it has been well fuſed, and afterwards cooled not too haſtily, and when its ſurface is not obliged to conform to the ſhape of any ſolid matter which touches it during the time of its hardening, its regular arrangement becomes ſenſible both externally and internally. This kind of cryſtalliſation forms then upon the upper ſurface of the regulus of antimony a ſort of ſtar, compoſed of many radii iſſuing from one center. Alchemiſts diſpoſed to the marvellous, imagined this to be very myſterious and ſignificative, and that it was nothing leſs than a ſtar appearing to magi or ſages to conduct them to the [illegible] of the king But this wonder has been reduced by Stahl in his *Op[illegible]um Chemicum*, and by Mr. Reaumur in a Memoir of 1724, to what it really is; that is, to the regular arrangement of the integrant parts of the regulus of antimony, when, by a perfect fuſion and ſlow cooling, they have had time and opportunity to place themſelves in that diſpoſition to which they naturally tend from their primary form: and ſince that time, chemiſts have found that this phenomenon is common to all metallic matters, which form, in ſimilar circumſtances, not ſtars, becauſe the integrant parts of each have peculiar ſhapes, but different figures no leſs regular and dependent on the form of theſe parts. It is an effect abſolutely ſimilar to the regularity of the figure of ſalts in their cryſtallization. *See* CRYSTALLIZATION.

Regulus of antimony is moderately hard, but, like the other ſemi-metals, it has no ductility, and breaks in ſmall pieces under a hammer.

It loſes $\frac{1}{7}$ part of its weight in water. The action of the air and of water deſtroys its luſtre, as it does to all imperfect metals, but it does not deſtroy and ruſt it ſo effectually as it does copper and iron.

This ſemi-metal is fuſible with a moderate heat, and as ſoon as it begins to be red-hot: but when it is heated to a certain degree, it fumes continually, and is diſſipated in vapors, becauſe it is ſemi-volatile, like the other ſemi-metals.

The fumes of regulus of antimony, when paſſing through air, form what are called *argentine flowers of regulus of antimony*. They are nothing but the earth of this ſemi-metal deprived of part of its inflammable principle, and capable of being reduced to the ſtate of regulus by its union with this principle. *See* FLOWERS (ARGENTINE).

This regulus, by calcination with a moderate fire, is deprived of more and more of its phlogiſton, and is changed ſucceſſively firſt into a grey calx capable of being fuſed by a ſtronger heat either into a vitreous and brittle matter, but brown or opake, or to a reddiſh tranſparent glaſs, according to its degree of calcination. The former matter is a *liver of antimony*, and the latter a *glaſs of antimony*. *See theſe words.*

If the calcination be continued longer, the calx of the regulus of antimony loſes more and more of its phlogiſton, color, volatility, fuſibility; and, laſtly, may be rendered ſimilar to the white calxes of antimony prepared by more expeditious proceſſes, called *diaphoretic antimony*, and *bezoard mineral.*

Nitre detonates with this ſemi-metal, and accelerates more or leſs, according to the quantity of it employed, but always conſiderably, theſe calcinations, as it does with all the imperfect metals.

Mineral acids diſſolve regulus of antimony very difficultly. Aqua regia is the beſt menſtruum of it. Nevertheleſs a very good combination of the marine acid with this metallic matter may be made by the proceſs for butter of antimony. Sulphur acts upon regulus of antimony, with which it forms a compound not different from mineral antimony. Liver of ſulphur diſſolves it effectually, and forms with it an *antimoniated liver of ſulphur*, more or leſs alkaline, from which a kermes mineral and golden ſulphur of antimony may be obtained.

We only ſlightly mention here theſe preparations of regulus of antimony. As they are made moſt commonly, and even moſt conveniently, with antimony, they are more particularly deſcribed under the article ANTIMONY, and under the articles of the ſeveral names by which they are known.

Regulus of antimony is ſeldom found within the earth in any other ſtate than mineraliſed by ſulphur, and in form of antimony. Mr. Anthony Swab mentions, in the Memoirs of the Swediſh Accademy for 1748, that he had found, in a mine near Salberg in Sweden, a regulus of antimony not mineraliſed.

Regulus of antimony is eaſily obtained pure and diſengaged from ſulphur, by the ordinary proceſs for obtaining metallic matters from their ores, that is, by calcining them, and thus depriving them of their mineraliſing ſubſtances, ſulphur and arſenic, and afterwards by fuſing the metallic earth with a matter proper to give it phlogiſton. Thus, by fuſing the grey calx of antimony, for inſtance, with black flux or ſoap, we ſhall obtain a fine regulus of antimony, as Kunckel has ſhewn, and as Mr. Geoffroy afterwards practiſed. But the ordinary method of making ſmall quantities of the regulus in laboratories, and deſcribed in books of chemiſtry, is more expeditious, becauſe calcination is avoided. It conſiſts in mixing four parts of crude antimony with three parts of tartar and one part and a half of nitre; in detonating this mixture, by parts, in a large red-hot crucible; and afterwards by raiſing the heat ſo as to produce fuſion. When the crucible is cold, it is to be broken, and at the bottom may be found a regulus of antimony lying under a ſaline ſcoria, from which it is eaſily ſeparated by the ſtroke of a hammer, as has been ſaid under the word *antimony*.

The nitre added in this operation conſumes quickly the largeſt part of the ſulphur of the antimony. The tartar is burnt and alkaliſed. This alkali, mixed with a part of the alkali of the nitre, ſeizes a portion of the ſulphur of antimony, with which it forms a liver of ſulphur; and this liver diſſolves in its turn a portion of the regulus of antimony, which conſequently remains in the ſcoria. The ſcoria alſo contains a certain quantity of vitriolated tartar formed by the acid of the portion of ſulphur, the phlogiſton of which has been burnt during detonation, and by a part of the alkalis of nitre and of tartar. As tartar enters largely into this mixture, and as it contains much oil, a ſufficient quantity of phlogiſton remains (as the quantity of nitre uſed is but ſmall) to reduce the earth of the antimony to a metallic ſtate.

We may eaſily perceive that this fuſion of the ore of regulus of antimony, with intention to ſeparate from it the regulus, has no other advantage than that of being very expeditious, becauſe the calcination, which is long, is avoided. But it does not procure all the metallic matter of the ore, ſince a part of it always is combined with the liver of ſulphur in the ſcoria; and alſo as regulus of antimony is volatile, much of it is diſſipated in fumes during the detonation. This method, therefore, which without this inconvenience would be well adapted for obtaining at once a metal from a crude ore, is evidently unfit for the purpoſe of eſſay, in which caſe, great care muſt always be taken that no liver of ſulphur be formed during the operation. For this reaſon the ore muſt be deprived very accurately of all its ſulphur by torrefaction before it is fuſed. Some chemiſts even avoid the uſe of alkaline fluxes, as the black and white fluxes, in fuſions for eſſays of ores, becauſe a ſmall quantity of ſulphur frequently adheres ſtrongly to the ore, notwithſtanding the calcination; and this method is certainly the ſafeſt and moſt accurate. But when the preciſe quantity of metal contained in the ore is not required, we may conveniently uſe this fuſion of crude mineral with crude flux, as is uſually done for the obtaining of regulus of antimony in chemical laboratories.

Regulus of antimony is one of the moſt important metallic matters, becauſe it furniſhes ſome very powerful remedies. When taken in ſubſtance, it is emetic and purgative, but is uncertain in its effects, becauſe it only acts when it is diſſolved, or corroded by the ſubſtances it meets in the primæ viæ, and becauſe theſe ſolvents are very various, according to the nature of the aliments, and alſo to the variable ſtate of the temperament. When the uſe of antimony was firſt introduced, ſmall globules of the regulus were taken internally, which paſſed through the inteſtinal canal, and laſtly were thrown out of the body along with the evacuations which they occaſioned. As theſe globules or pills were neither diminiſhed nor altered ſenſibly after theſe operations, and as they were capable of ſerving an indefinite number of times, they were called *perpetual pills*. Cups alſo were made of the regulus of antimony, in which wine being left, acquired a purgative quality; but as the wine diſſolved more or leſs in proportion to the quantity of acid contained in it, and as wine is very various in this reſpect, hence the effects of this wine were not more certain than thoſe of the perpetual pills. Since the diſcovery of better antimonial preparations, theſe ancient remedies have been neglected. Their uncertainty, and even the dangerous accidents which they frequently occaſion, have undoubtedly contributed not a little to the oppoſition that many phyſicians, otherwiſe perſons of merit, made for a long time to the uſe of antimony, when it was firſt introduced into medicine. The famous quarrels excited concerning antimony are well known. On both ſides of this conteſt there were ſome reaſon and ſome error. They who rejected the uſe of antimony certainly erred in proſcribing a ſubſtance capable of furniſhing ſo excellent remedies; and the moſt zealous partiſans of it were too extravagant in their praiſes, at a time when its qualities and the methods of preparing it were not well known, and when the effects of the antimonials then adminiſtered were ſo uncertain and dangerous.

Regulus of antimony is alſo uſeful in many arts. It enters into the compoſitions for metallic ſpeculums of teleſcopes, and for printing types.

According to Mr. Geoffroy's table of affinities, it unites with metals in the following order. Iron, copper, ſilver, and lead; and according to Mr. Gellert, with zinc, iron, copper, tin, lead, ſilver, biſmuth, gold.

DLXXXIX. REGULUS (MARTIAL) *of* ANTIMONY, *or* Regulus *of* Antimony Precipitated *by* Metals. Regulus of antimony has much leſs affinity with ſulphur than moſt other metallic matters, as iron, copper, tin, lead, ſilver, and biſmuth. Accordingly, when crude antimony is fuſed with a ſufficient quantity of any of theſe metals, the reguline part may be ſeparated from the ſulphur. A true precipitation is then made by the dry way. As iron, of all metals, has moſt affinity with ſulphur, it is preferable to any other for the ſeparation of regulus of antimony by this precipitation.

The proceſs uſed for that purpoſe conſiſts in making ſome horſeſhoe-nails white-hot in a crucible (theſe nails being ſoft iron and eaſily fuſible with ſulphur), to which is to be added twice their weight of crude antimony, and in procuring by a ſtrong heat a fuſion of the whole, after having covered the crucible. The iron which unites with the ſulphur of the antimony is by its means perfectly fuſed; and, being rendered lighter than the reguline part of the antimony then deprived of ſulphur, riſes to the upper part of the melted maſs, while the regulus ſinks to the bottom.

If the fuſion has been compleat, we ſhall find upon breaking the crucible, when cold, a fine regulus of antimony covered with a hard ſcoria, which is a combination of iron with the ſulphur of antimony. The moſt eſſential point to be attended to in this operation is to give a ſufficient heat for a perfect fuſion; but as this heat muſt be very ſtrong, moſt of the proceſſes directed in books for the preparation of this regulus, order the addition of a quantity of nitre equal to a fifth part of the antimony employed, as ſoon as the fuſion commences. This nitre detonates with the phlogiſton of the ſubſtances contained in the mixture, its detonation makes it conſiderably more fluid, and this nitre, when alkaliſed, mixing with the ſcoria, forms a liver of ſulphur, which diſſolves a portion of the metals, and makes the ſcoria more fluid by giving to it a ſaline quality.

Lemery and many others direct, that the regulus ſhould be afterwards fuſed thrice, and that in the firſt of theſe three fuſions an eighth part of crude antimony, with the ſame quantity of nitre as in the former fuſion, ſhould be added, and the nitre only in the two latter fuſions.

The crude antimony added in the ſecond fuſion is intended to carry off by means of its ſulphur a part of the iron which may be united with the regulus, and the nitre which is to be added in each of the following fuſions is intended to purify further the regulus from any remaining portion of ſulphur. The intention then of all theſe preparations is only to obtain a pure regulus of antimony, which may be obtained otherwiſe much more eaſily. *See the preceding article.*

DXC. REGULUS *of* ARSENIC. This is white arſenic, to which the properties of a ſemi-metal have been given, by combining it properly with a ſufficient quantity of phlogiſton.

Regulus of arſenic may be made by ſeveral methods. The proceſs anciently uſed for this purpoſe conſiſted in mixing four parts of arſenic with two parts of black flux, one part of borax, and one part of filings of iron, or of copper and quickly fuſing the mixture in a crucible. When the operation is finiſhed a regulus of arſenic will be found at the bottom of the crucible, of a white livid color, and conſiderably ſolid. The iron and copper employed in this proceſs are not intended, as in the operation for the martial regulus of antimony, to precipitate the arſenic, and to ſeparate it from ſulphur or any other ſubſtance; for the white arſenic is pure, and nothing is to be taken from it, but, on the contrary, the inflammable principle is to be added to reduce it to a regulus. The true uſe of theſe metals in the preſent operation is to unite with the regulus of arſenic, to give it more body, and to prevent its entire diſſipation in vapors. Hence the addition of iron, while it procures theſe advantages, has the inconveniency of altering the purity of the regulus: for the metallic ſubſtance obtained is a regulus of arſenic allayed with iron. It may, however, be purified from the iron by ſublimation in a cloſe veſſel; by which operation the reguliſed arſenical part, which is very volatile, is ſublimed to the top of the veſſel, and is ſeparated from the iron, which, being of a fixed nature, remains at the bottom. We are not, however, very certain that in this kind of rectification, the regulus of arſenic does not carry along with it a certain quantity of iron, for in general a volatile ſubſtance raiſes along with it, in ſublimation, a part of any fixed matter with which it happened to be united.

Mr. Brandt propoſes another method, which we believe is preferable to that deſcribed. He directs that white arſenic ſhould be mixed with ſoap. Inſtead of the ſoap, olive oil may be uſed, which I have found to ſucceed well. The mixture is to be put into a retort or glaſs matraſs, and to be diſtilled or ſublimed with a fire at firſt very moderate, and only ſufficient to raiſe the oil. As the oils, which are not volatile, cannot be diſtilled but by a heat ſufficient to burn and decompoſe them, the oil therefore which is mixed with the arſenic undergoes theſe alterations, and after having penetrated the arſenic thoroughly, is reduced to a coal. When no more oily vapors riſe, we may then know that the oil is reduced to coal. Then the fire muſt be encreaſed, and the metalliſed arſenic will be ſoon ſublimed to the upper part of the veſſel, in the inſide of which it will form a metallic cruſt. When no more ſublimes, the veſſel is to be broken, and the adhering cruſt of regulus of arſenic is to be ſeparated. The regulus obtained by this firſt operation is not generally perfect, or not entirely ſo, as a part of it is always overcharged with fuliginous matter, and another part has not enough of phlogiſton, which latter part adheres to the inner ſurface of the cruſt, and forms grey or brown cryſtals. This ſublimate muſt then be mixed with a leſs quantity of oil, and ſublimed a ſecond time like the firſt; and even, to obtain as good a regulus as may be made, a third ſublimation in a cloſe veſſel, and without oil, is neceſſary. During this operation, the oil which riſes is more fetid than any other empyreumatic oil, and is almoſt inſupportable. This ſmell certainly proceeds from the arſenic, the ſmell of which is exceedingly ſtrong and diſagreeable, when it is heated.

Regulus of arſenic, made by the method I have deſcribed, and which I conſider as the only one which is pure, has all the properties of a ſemi-metal. It has metallic gravity, opacity, and luſtre. Its color is white and livid, it tarniſhes in the air, is very brittle, but much more volatile than any other ſemi-metal. It eaſily loſes its inflammable principle, when ſublimed in veſſels into which the air has acceſs; the ſublimate having the appearance of grey flowers, which by repeated ſublimations become entirely white, and ſimilar to white cryſtalline arſenic.

When regulus of arſenic is heated quickly and ſtrongly in open air, as under a muffle, it burns with a white or bluiſh flame, and diſſipates in a thick fume, which has a very fetid ſmell, like that of garlic.

Regulus of arſenic may be combined with acids and moſt metals. As white arſenic alſo can unite with theſe ſubſtances, we refer to that article. We ſhall only obſerve here, that, according to Mr. Brandt, in the Swediſh Memoirs, the regulus of arſenic cannot be united with mercury. Altho' the phenomena exhibited by white arſenic and regulus of arſenic in ſolutions and allays are probably the ſame, yet an accurate compariſon of theſe would deſerve notice, eſpecially if the regulus employed were well made; for ſome difference muſt proceed from the greater or leſs quantity of phlogiſton with which it is united. *See* ARSENIC.

DXCI. REGULUS *of* COBALT. Regulus of cobalt is a ſemi metal lately diſcovered, and not yet perfectly well known. It receives its name from cobalt, becauſe it can only be extracted from the mineral properly ſo called.

The proceſs by which this ſemi-metal is obtained is ſimilar to thoſe generally uſed for the extraction of metals from their ores. The cobalt muſt be thoroughly torrefied to deprive it of all the ſulphur and arſenic it contains, and the unmetallic earthy and ſtoney matters muſt be ſeparated by waſhing. The cobalt thus prepared is then to be mixed with double or triple its quantity of black flux, and a little decrepitated ſea-ſalt, and muſt be fuſed either in a forge or in a hot furnace. For this ore is very difficult of fuſion.

When the fuſion has been well made, we find upon breaking the crucible, after it has cooled, a metallic regulus covered with a ſcoria of a deep blue color. The regulus is of a white metallic color. The ſurface of its fracture is cloſe and ſmall grained. This ſemi-metal is hard, but brittle. When the fuſion has been well made, its ſurface appears to be carved with many convex threads which croſs each other diverſely. As almoſt all cobalts contain alſo biſmuth, and even as much as of the regulus itſelf, this biſmuth is reduced by the ſame operation, and precipitated in the ſame manner as the regulus of cobalt; for although theſe two metals are frequently mixed in the ſame mineral, that is, in cobalt, they are incapable of uniting together, and are always found diſtinct and ſeparate from one another when they are melted together. At the bottom of the crucible then we find both regulus of cobalt and biſmuth. The latter, having a greater ſpecific gravity, is found under the former. They may be ſeparated from each other by the blow of a hammer. Biſmuth may be eaſily diſtinguiſhed from the regulus of cobalt, not only from its ſituation in the crucible, but alſo by the large ſhining facets which appear in its fracture, and which are very different from the cloſe, aſh-colored grain of regulus of cobalt.

This ſemi-metal is more difficult of fuſion than any other, is leſs eaſily calcinable, and much leſs volatile. Its calx is grey, and more or leſs brown, and when fuſed with vitrifiable matters, it changes into a beautiful blue glaſs called *ſmalt*. This calx then is one of thoſe which preſerve always a part of their inflammable principle. It is ſoluble in acids as the regulus is. This regulus is ſoluble in vitriolic, marine, nitrous acids, and in aqua regia, to all which it communicates colors. The ſolution in vitriolic acid is reddiſh; the ſolution in marine acid is of a fine bluiſh-green when hot, and its color is almoſt totally effaced when cold, but is eaſily recoverable by heating it, without being obliged to uncork the bottle containing it. This ſolution of the calx or regulus of cobalt is the baſis of the ſympathetic ink, for without marine acid this ink cannot be made. *See* INK (SYMPATHETIC).

All the ſolutions of regulus of cobalt may be precipitated by alkalis, and theſe precipitates are blue, which color they retain when vitrified with the ſtrongeſt fire.

Not only ſympathetic ink, but alſo regulus of cobalt, may be made from the *zaffre* commonly ſold, which is nothing elſe than the calx of regulus of cobalt mixed with more or leſs pulveriſed flints. For this purpoſe we muſt ſeparate as well as we can the powder of flints from it by waſhing, as Mr. Beaumé does, and then reduce it with black flux and ſea-ſalt.

Regulus of cobalt ſeems incapable of uniting with ſulphur, but it eaſily unites with liver of ſulphur, and the union it forms is ſo intimate, that Mr. Beaumé could not ſeparate theſe two ſubſtances, otherwiſe than by precipitation with an acid.

Many curious and intereſting remarks are ſtill to be diſcovered concerning this ſingular ſemi-metal, and we may hope to receive further information from the endeavors of chemiſts who have undertaken the examination of it. Mr. Beaumé particularly has made conſiderable experiments on this ſubject, part of which he communicates to the public in his Courſe of Chemiſtry. All the new remarks in this article are from him. We wiſh that this able chemiſt would publiſh the numerous experiments [illegible] has made on this ſubject. *See* COBALT, INK (SYMPATHETIC), AZURE, [illegible], *and* SMALT.

DXCII. RESIN. The name *reſin* in its moſt general ſenſe might be applied to all ſolid or concrete oily ſubſtances, not only thoſe particularly called *reſins*, as *maſtich*, *ſandarach*, *white pitch*, &c. but alſo to wax, butter, fat, &c. But theſe concrete oily matters differ ſo much from each other, that they ought to be more particularly diſtinguiſhed.

Firſt, we may obſerve, that every ſolid oily ſubſtance owes its conſiſtence to a ſaline, and eſpecially to an acid matter; for we know that a liquid oil may be rendered thick by the addition of an acid, in proportion to the quantity of acid, and intimacy of combination. We alſo know, that by decompoſing concrete oils by diſtillation, we obtain a quantity of acid ſo much greater, or ſo much ſtronger, as this oil is thick or more ſolid; or at leaſt, that the quantity of liquid oil obtained by this diſtillation is proportionable to the quantity of acid ſeparated.

But all concrete oils may be naturally combined with a ſufficient quantity of acid, to give it this conſiſtence, in two manners; for either they have received originally from nature a ſufficient quantity of acid, or elſe, being formed originally fluid, they have loſt by evaporation the part which is the moſt thin, moſt volatile, and leaſt charged with acid, or leaſt perfectly combined with acid; by which the proportion of well combined acid is more and more encreaſed in the portion which is not evaporated, and which is therefore rendered thicker.

According to this diſtinction, concrete oils are naturally divided into two claſſes, the former comprehending thoſe which are always found in a ſolid ſtate, as wax, butter, and the fat of animals, and the latter comprehending the thickened or conſolidated reſiduums of oils, which, from a liquid ſtate, have become concrete by the diſſipation and evaporation of their moſt fluid part. This ſecond claſs includes all concrete oils, to which the name of reſins has been applied. The properties of all concrete oils of the former claſs ſhew inconteſtably that theſe oils, or oily concretions, are of the kind of oils which are moſt ſweet, moſt unctuous, leaſt inflammable, and leaſt volatile. Accordingly, all theſe matters reſemble each other eſſentially, and only differ from one another by their greater or leſs ſolidity: but the reſins or concrete oils of the ſecond claſs are very different from one another, ſome of them having a ſtrong aromatic ſmell, and diſſolving eaſily and entirely in ſpirit of wine, and others having little or no ſmell, at leaſt when cold, and being totally unſoluble in ſpirit of wine; ſuch as *gum-copal* Theſe properties ſo different amongſt ſubſtances, confounded under one general name, ſhew that the liquid oils whence they were formed were eſſentially different. The former reſins ought to be conſidered as the reſiduums of eſſential oils and natural balſams, ſince they evidently retain the principal properties of theſe. The latter can only be the reſiduums of certain oils not volatile, unſoluble in ſpirit of wine, but capable of becoming rancid, thick, and dry; as oil of linſeed, hemp, nuts, &c. for theſe oils, kept a long time in a dry place, in open ſhallow veſſels, become concrete, tranſparent, deprived of all ſmell, and unſoluble in ſpirit of wine, like the reſin called *gum-copal.* Natural reſins of this latter claſs are much rarer than thoſe of the former, becauſe more vegetables have a ſuperabundant eſſential oil than a ſuperabundance of drying oil, which is not volatile; or, at leaſt, this ſecond kind of oil is leſs eaſily evaporable than the former.

Reſinous matters have not been ſufficiently examined. We might probably find many of them ſimilar to copal, and alſo others, which, proceeding from the two kinds of oils above deſcribed, mixed and evaporated together, would partake at the ſame time of the two kinds of reſins reſulting from theſe, and would hold a ſimilar relation to the two kinds of reſins which gum-reſins hold to gums and reſins. Amber and other ſolid bitumens, which alſo are oily concrete matters, unſoluble in ſpirit of wine, and evidently of vegetable origin, are probably formed by oils not volatile, thickened and hardened by age, or by intimate combination with mineral acids.

Reſins, being only thickened balſams, are collected, as theſe balſams are, upon trees and plants from which they have exſuded. Several of them are obtained by art. Such is the *black pitch*, which is obtained by making it melt and exſude, by means of heat, from firs, pines, and other trees of this kind, which contain large quantities of it. Such alſo are the reſins of jalap, ſcammony, and turpeth, which are obtained for medicinal uſes, by digeſting the vegetables containing them previouſly well dried, in ſpirit of wine, from which they are afterwards ſeparated by adding a large quantity of water.

Reſins are employed for many purpoſes. The cheapeſt kinds are uſed for torches, and to cover the outſides of ſhips and boats. The fine, tranſparent reſins compoſe varniſhes. Many of them are employed medicinally; either externally, as, for inſtance, thoſe which enter into the compoſition of ointments and plaſters; or internally, as the reſins of ſcammony, jalap, turpeth, which are purgative. Other reſins, the ſmell of which is agreeable, as, for inſtance, benjamin and ſtorax, are employed as perfumes. *See the articles* BALSAMS, BITUMENS, OILS, *and* GUM-RESINS. *See alſo the Dictionary of Natural Hiſtory for the particular detail of the different kinds of reſins and their uſes.*

DXCIII. RETORT. Retorts are veſſels employed for many diſtillations, and moſt frequently for thoſe which require a degree of heat ſuperior to that of boiling water. This veſſel is a kind of bottle with a long neck ſo bent, that it makes with the belly of the retort an angle of about ſixty degrees. From this form they have probably been named *retorts*. The moſt capacious part of the retort is called its *belly*. Its upper part is called the *arch* or *roof of the retort*, and the bent part is the *neck*. *See* PLATE I. *Fig.* 1. *and* 2.

Retorts differ in form and materials: their bellies are generally round: ſome of them are oblong and ſhaped like a cucurbit: theſe are called *Engliſh retorts*. They are preferable for the diſtillation of matters which are ſubject to ſwell and to paſs into the receiver before they be decompoſed.

A retort which has a little hole pierced in its roof is called a *tubulated retort*. This hole muſt be capable of being exactly cloſed with a ſtopper of proper materials. Retorts of this kind are employed in diſtillations, where ſome matter muſt be introduced into the retort after the receiver is joined to it, as in the diſtillation of ſmoking marine acid, and in the operations for procuring the ſeveral kinds of *clyſſus*.

If the retort be well made, the above-mentioned inclination of its neck muſt be moſt favorable to diſtillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is alſo by this form brought too near the furnace. If the neck be too [illegible] inclined, the vapors or liquors which riſe in diſtillation can ſcarcely flow into the receiver from want of ſufficient deſcent, and only circulate in the belly of the retort. Retorts, when too ſtrait in their bending, are very faulty. This form muſt be an impediment to diſtillation: the paſſage therefore from the belly to the neck of the retort muſt be free and wide, and gradually diminiſhing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are uſed in chemical operations, of common glaſs, cryſtal-glaſs, ſtone-ware, iron. Retorts of glaſs are uſed for all operations which require a leſs heat than is ſufficient for their fuſion. Earthen retorts are neceſſary where great heat is requiſite, as in the preparation of phoſphorus. Iron retorts are not much uſed, as they can only ſerve for the diſtillation of ſubſtances which cannot act upon this metal, and as theſe ſubſtances are few in number. They can ſeldom be employed but for the diſtillation of mercury and of animal matters.

DXCIV. REVERBERATORY. *See* FURNACE.

DXCV. REVIVIFICATION. *See* REDUCTION.

DXCVI. RHUBARB. (*n*)

DXCVII. RISIGAL. The ſame as REALGAR.

DXCVIII. ROASTING *of* ORES. *See* SMELTING *of* ORES.

DXCIX. ROSEMARY. (*o*)

DC. RUBIN *of* ANTIMONY. This is a kind of liver of antimony, made with equal parts of nitre and crude antimony detonated together, to which is afterwards added an equal part of common ſalt; but as the addition of the ſalt is uſeleſs, the preparation is not now employed. It is alſo called *magneſia opalina*. *See* ANTIMONY *and* LIVER *of* ANTIMONY.

DCI. RUBY (ARSENICAL). This preparation is red realgar, to which, by fuſion and cooling, a tranſparency is given which makes it reſemble a ruby; in which reſpect only it differs from realgar. *See* REALGAR.

(*n*) RHUBARB. An ounce of Rhubarb, reduced into groſs powder, yielded with highly rectified ſpirit of wine three drams of extract, and afterwards with water two drams, two ſcruples and a half: the reſiduum weighed two drams twelve grains. By applying water firſt to another ounce, five drams, two ſcruples and a half of extract were obtained, and of the reſiduum five grains only were ſoluble in ſpirit of wine. Rhubarb appears from theſe experiments to contain much more gummy or mucilaginous than reſinous matter; and hence ſpirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of moſt other vegetables.

The yellow color of rhubarb is remarkably leſs deſtructible than many other vegetable yellows. Aqua fortis and other acids, which deſtroy the color of ſaffron, turmeric, &c. make no change in that of rhubarb, or at moſt render it only turbid. Volatile ſpirits heighten the color, and incline it to red. Fixed alkaline ſalts have this effect in a greater degree. Solutions of green vitriol and other chalybeate liquors, change the color of infuſions of rhubarb to an inky blackneſs; a mark that this root is poſſeſſed of an aſtringent quality. The ſpirituous extract does not purge, although the extract made by water after ſpirit does, as if its purgative quality reſided chiefly in a combination of gummy and ſaline matter. *Neuman.*

(*o*) ROSEMARY. The only active principle in this plant is the eſſential oil. The gummy extract, diveſted of the oil, has no remarkable taſte any more than ſmell. The reſinous extract retains a conſiderable part of the flavor of the herb, and of the eſſential oil. Its fragrance is communicated by infuſion or by diſtillation to ſpirit or to water. Vinous ſpirit, impregnated by diſtillation with the flavor of roſemary, is called *Hungary-water*. The flowers of this plant contain little or no ſmell, and no oil could be collected from the diſtilled water; but from forty-eight ounces of leaves, three drams and half a ſcruple of oil were obtained by diſtillation. Tournefort obſerves, that thoſe ſorts of roſemary, which produce neither flowers nor ſeeds, and which have very hard ſhrubby ſtalks [illegible] ſmell ſtrongly like camphor [illegible] on diſtilling a large quantity [illegible] of obtaining their oil a po[illegible] camphor. *Neuman.*

DCII. **RUST.** This name is particularly applicable to the earth of iron decomposed by the action of water and of air; but it may be given to the earth of any other metal capable of ſuch decompoſition, as copper, and all other metallic matters, excepting the perfect metals. Thus verdegriſe might be called the ruſt of copper. The kind of *ceruſs* formed upon lead, expoſed to a humid air, may be called *ruſt of lead*, &c. *See the articles of the ſeveral metallic matters.*

DCIII

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DCIII. SAFFRE. *See* ZAFFRE.

DCIV. SAFFRON. (*p*).

DCV. SAFFRON *of* IRON. Chemiſts have given the name *ſaffron* to many preparations which have a yellow color, like that of ſaffron, and particularly to the earth or ruſt of iron which has that color.

As iron may be deprived of its phlogiſton by the combined action of air and of water, by that of air and fire, and, laſtly, by acids, different names have been given to ſaffrons of Mars, or ferruginous earths prepared by theſe ſeveral agents. The ruſt of iron made by humid air is called *martial ſaffron prepared with dew*, or *aperitive ſaffron of Mars*. Iron, dephlogiſticated by vitriolic acid or ſulphur, is alſo called *aperitive ſaffron of Mars*. Laſtly, that which is reduced into a calx by the action of fire, is called *aſtringent ſaffron of Mars*. *See, for the medicinal virtues of theſe preparations of iron, the articles* ETHIOPS MARTIAL *and* IRON.

As the ſaffrons of iron acquire different ſhades of red and orange colors, which they preſerve when melted with very fuſible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glaſs, or imitations of precious ſtones.

(*p*) SAFFRON. Both water and ſpirit extract the color and virtue of ſaffron. The former liquor improves the ſmell and heightens the color, whilſt the ſpirit ſeems rather to weaken both. By drying two ounces and a half of the beſt ſaffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding ſtrong ſmell, but had not the appearance of oil. This is the active part of the ſaffron, which diſorders the head and ſenſes. Six drams of extract were obtained from an ounce of dried ſaffron by means of water, and five drams and one ſcruple were obtained from another ounce by means of ſpirit. Rectified ſpirit acquired no ſmell or taſte by diſtillation from dried ſaffron; but water being thus diſtilled acquired a ſtrong ſmell. *Neumann.*

DCVI. SAFFRON *of* METALS. Saffron of metals is the metallic earth of antimony, half deprived of its ſulphur and phlogiſton by detonation of crude antimony with nitre, and afterwards well waſhed; or it is liver of antimony deprived of all ſaline matter by a ſufficient waſhing. This preparation is a violent and uncertain emetic, not uſed by prudent phyſicians. *See* LIVER *of* ANTIMONY, *and* TARTAR (EMETIC).

DCVII. SALMIAC. This word is an abridgement uſed by ſome for ſal ammoniac. *See* AMMONIAC (SAL).

DCVIII. SALT. The word ſalt, which is ſynonimous with ſaline matter or ſaline ſubſtances, when taken in its moſt general ſenſe, is of all chemical terms that which is applicable to the greateſt number of individuals. In fact, the number of different bodies, which have what chemiſts call a ſaline character, or which poſſeſs the principal ſaline properties, is ſo great that they are very far from being all known, as we ſhall afterwards ſee.

The eſſential properties of all matter, which ought to be conſidered as ſaline, are, to affect the ſenſe of taſte, to be ſoluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt thoſe of water and of pure earth.

If we attend a little to the principal properties of the ſeveral bodies which are conſidered as ſalts or ſaline ſubſtances, we ſhall eaſily find that they do not all poſſeſs in the ſame degree the eſſential ſaline qualities that we have deſcribed. We ſhall ſee that ſome ſalts poſſeſs theſe qualities in the higheſt degree, while in others they are ſo weak and indiſtinct, that in many of them they can ſcarcely be diſcovered; and this diminution of the ſaline properties is ſo conſiderable in many compound bodies, that we may affirm that the limits which ſeparate ſaline matters from others that are not ſaline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other ſide, that the ſaline ſubſtances whoſe properties are moſt diſtinct and ſtrong, ſuch, for inſtance, as the mineral acids, have great power over many other ſubſtances which have not a ſaline property; to which, by being combined together, they communicate more or leſs of their ſaline properties; or rather with which they form compounds, in which the ſaline properties are more or leſs ſenſible. Since experience ſhews that theſe ſaline compounds may be decompoſed, ſo that the ſubſtance, which is not ſaline, ſhall be ſeparated in its former ſtate from the ſaline matter, which alſo ſhall recover the ſaline properties in the ſame force which it had before this union, we may from thence conclude;

Firſt, that among the infinite multitude of bodies in which we may perceive ſaline properties, a very great number are compoſed of a ſubſtance eſſentially ſaline, and of one or more other ſubſtances not ſaline.

Secondly, that we ought to diſtinguiſh well ſubſtances which eſſentially poſſeſs ſaline properties from thoſe which, not poſſeſſing any ſuch properties themſelves, are only capable of receiving more or leſs of them by uniting with ſubſtances of the former kind.

Thirdly, as the number of matters not ſaline which are capable of acquiring a ſaline character, or rather of forming compounds more or leſs ſaline by their union with ſubſtances eſſentially ſaline, is very great, the number of theſe laſt muſt be very ſmall, in compariſon of the number of compounds in which ſaline properties are perceptible.

To give ſome explanation of this extenſive ſubject, we muſt begin by determining preciſely what ſubſtances eſſentially ſaline are, and by aſſigning a character which can diſtinguiſh them from thoſe, which, without containing any thing ſaline, may nevertheleſs make part of ſalts, by the union they are capable of contracting with the former. Theſe characters are the following:

All thoſe ſubſtances ought to be conſidered as eſſentially ſaline which have not only the characteriſtic properties of ſalts, as taſte and perfect miſcibility with water, in an eminent degree, but which alſo when diſengaged can communicate theſe properties, at leaſt in part, to other ſubſtances which have them not, by combining with theſe latter, from which, when afterwards ſeparated, they reſume their former ſtate and peculiar ſaline characters.

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, muſt be conſidered as ſubſtances eſſentially ſaline. Each of theſe bodies has the properties we have mentioned. Some other ſubſtances have not the properties of acids or of alkalis very diſtinctly; but as they have the properties of ſalts in general, and are capable of acting as acids, and of communicating ſaline properties to the compounds into which they enter, they may therefore be conſidered as ſubſtances eſſentially ſaline. Such are *arſenic* and *ſedative ſalt.*

But if we reflect a little on the particular properties of each of the ſubſtances which ſeem to be eſſentially ſaline, we ſhall obſerve that they do not all poſſeſs theſe properties in the ſame degree. How great the difference is in this reſpect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can ſcarcely be known to be ſubſtances of the ſame kind. The taſte ſimply acidulous of cream of tartar, its ſtate of conſtant cryſtallization and dryneſs, its little ſolubility in water, laſtly, the weakneſs of the adheſion which it contracts with all the ſubſtances with which it can unite, cannot be compared with the ſtrong and corroſive taſte of vitriolic acid, with the activity of its ſeizing moiſture, with the ſurprizing heat occaſioned by its mixture with water, laſtly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The ſlighteſt view of the other ſubſtances eſſentially ſaline is ſufficient to ſhow that they differ much from each other, particularly in their degree of ſtrength; in a word, that they do not poſſeſs the ſaline properties in the ſame degree.

Theſe are the conſiderations which have undoubtedly determined the greateſt chemiſts, particularly Stahl, to believe that the number of ſubſtances truly and eſſentially ſaline is very ſmall, and even that only one ſaline principle exiſts, which by the intimate union it is capable of contracting with ſeveral other ſubſtances, conſtitutes a certain number of matters which poſſeſs the ſaline properties in a degree ſufficiently ſtrong to preſerve theſe properties more or leſs in their ſeveral combinations with other matters that are not ſaline, and to recover them entirely when ſeparated from theſe combinations; ſo that as they do not themſelves undergo any decompoſition, and as they always appear again with the ſame properties after having been combined and ſeparated, they ſeem to be ſimple matters, eſſentially ſaline, although they really are compounds of ſeveral bodies, not ſaline, united intimately with one only ſaline principle, which is univerſal and always the ſame.

According to this notion, which is grand and perfectly analogous to the plan which nature ſeems conſtantly to purſue in the different orders of compounds, the queſtion is to diſcover which is the moſt ſimple of all ſaline ſubſtances, and is the principle of all others. The beſt, and perhaps the only, method of determining in a queſtion of this nature, is to compare together the ſeveral ſaline ſubſtances, and to conſider that as the moſt ſimple of all, which poſſeſſes the ſaline properties in the moſt eminent degree, and which alſo appears upon all occaſions to be leaſt ſuſceptible of decompoſition or alteration; for all chemiſtry ſhews us, that theſe are the characters of the moſt ſimple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the ſaline matters under this point of view, we ſhall ſoon eaſily diſcover that we muſt begin by excluding all the ſaline matters called *neutral ſalts*; for any of theſe ſalts may be decompoſed by ordinary chemical operations; and theſe decompoſitions ſhow that many of them are compoſed of two ſimpler ſaline ſubſtances, one of which is called *acid*, and the other *alkali*; alſo, acids and alkalis are not in general ſo eaſily altered as neutral ſalts. In the claſſes therefore of theſe two ſaline ſubſtances, we muſt ſearch for that which is the moſt pure and ſimple of all.

If we continue this inquiry upon the ſame principles, and compare together the ſaline properties of the pureſt and ſtrongeſt acids and alkalis, we ſhall eaſily be convinced that the ſaline properties are ſtronger and more diſtinct in acids than in alkalis, ſince the former are more active, more diſſolving, more adhering to the bodies diſſolved, more deliqueſcent, &c. and alſo, that in the ſeveral operations of chemiſtry, alkalis fixed and volatile appear to be more ſuſceptible of alteration and decompoſition than acids. Amongſt acids, therefore, we muſt ſearch for the ſtrongeſt and ſimpleſt ſaline matter.

Laſtly, when we examine in the ſame manner, and compare together all the ſubſtances which have the principal properties of acids, and which are called acids, we ſhall clearly perceive that thoſe which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and ſuſceptible of alteration than acids deprived of all oil, which we call mineral acids; amongſt which, the vitriolic will be eaſily diſcovered to be the ſtrongeſt and moſt unalterable, and conſequently of all bodies which have ſaline properties, the pureſt, ſimpleſt, and the moſt ſenſibly and eſſentially a ſalt.

Such conſiderations have undoubtedly induced the moſt profound chemiſts, and eſpecially the illuſtrious Stahl, to conſider this acid as the pureſt and ſimpleſt of all ſaline matters; and indeed all who are capable of reflecting on the greateſt and moſt important phenomena of chemiſtry, will conſider this propoſition as a demonſtrated truth. But Stahl carries this notion ſtill farther. From his writings, and the whole of his doctrine, we may infer, firſt, "That "he conſiders the vitriolic acid as the only ſubſtance eſſentially ſaline; as the "only ſaline principle, which, by uniting more or leſs intimately with other "ſubſtances that are not ſaline, is capable of forming an innumerable multi-"tude of the other ſaline matters which nature and art ſhew to us; and,

“ ſecondly, that this ſaline principle is a ſecondary principle, compoſed only of “ the intimate union of two primary principles, *water* and *earth*.”

Every true chemiſt will eaſily diſcover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by ſaline ſubſtances. But we muſt at the ſame time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its conſiſtency with the principles of chemiſtry, and with many phenomena, yet it is not ſupported by a ſufficient number of facts and experiments to aſcertain its truth.

We might here examine what degree of probability ought to be granted to this theory of ſalts, but this could not be properly accompliſhed without entering into long details, and penetrating into the depths of chemiſtry; in a word, without making a full and compleat treatiſe, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is moſt eſſential to be known concerning this grand hypotheſis. We may perceive at once, that the former of theſe propoſitions, upon which is founded the theory which we mentioned, cannot be demonſtrated, unleſs it be previouſly proved that every ſaline matter, excepting pure vitriolic acid, is nothing but this ſame acid differently modified, the primary properties of which are more or leſs altered or diſguiſed by the union contracted with other ſubſtances. But we confeſs, that chemiſts are not capable of proving deciſively this opinion; which, however, will appear very probable from the following reflections.

Firſt, of all ſaline matters known, none is ſo ſtrong, ſo unalterable, ſo eminently poſſeſſed of ſaline properties, as *vitriolic acid*.

Secondly, amongſt the other ſaline ſubſtances, thoſe which appear moſt active, and moſt ſimple, as *nitrous* and *marine acids*, are at the ſame time thoſe, whoſe properties moſt reſemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteriſtic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we ſee in the volatile ſulphureous acid. *See* Acid (Volatile Sulphureous), *and* Acid (Nitrous): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters ſuſceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of theſe matters.

Fourthly, the marine acid, altho' its principles are leſs known than thoſe of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with ſpirit of wine, as vitriolic acid does, which it cannot do in its natural ſtate; and when iron is diſſolved in it, it ſeems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid ſeems not impoſſible. Having once diſtilled very pure vitriolic acid upon a conſiderable quantity of white arſenic, I was ſtruck with a ſtrong ſmell like that of marine acid, which was not either that of arſenic or of vitriolic acid; for this has no ſmell, when it is pure.

Fifthly, oily vegetable acids become ſo much ſtronger, and more ſimilar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining them with alkalis, earths, or metals, and afterwards by ſeparating them from theſe ſubſtances, by diſtillation, and eſpecially by frequently repeating theſe operations. They might perhaps be reduced to a pure vitriolic acid, by continuing ſufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or ſtill better with ſpirit of wine, acquire the characters of vegetable acids. We may ſee a remarkable inſtance of this in Mr. Pott's *Diſſertation de Acido Nitri Vinoſo.*

Sixthly, the properties of fixed alkalis ſeem to be very different from thoſe of acids in general, and conſequently of vitriolic acid. Yet if we conſider that a large quantity of earth enters their compoſition; that much of it may be ſeparated by repeated ſolutions and calcinations; and alſo that by depriving theſe ſaline ſubſtances of their earthy principle, they become leſs fixed, more deliqueſcent, and, in a word, more ſimilar to vitriolic acid in this reſpect; we ſhall not think it improbable, that fixed alkalis owe their ſaline properties to a ſaline principle of the nature of vitriolic acid, but much diſguiſed by the quantity of earth, and probably of inflammable principle, to which it is united in theſe combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in ſeveral diſtillations, ſeem to ſhew ſufficiently that they are matters eſſentially ſaline, as fixed alkalis are, and that their volatility which diſtinguiſhes them proceeds from their containing a leſs quantity of earth, but more attenuated, and a portion of very ſubtle and volatile oil, which enters their compoſition.

Beſides theſe principal facts, there are many others, too numerous to be even ſlightly mentioned here: they may be found ſcattered in the works of chemiſts, particularly of Stahl. But perſons who would collect and compare all the experiments relating to this ſubject, ought to know, that many of them are not ſufficiently aſcertained, and that perhaps a greater number of them have not been ſufficiently proſecuted, and are, properly ſpeaking, only begun. We muſt even acknowledge, that many of thoſe experiments which we have mentioned have not been ſufficiently proſecuted. *See all the articles of acids and alkalis.*

The ſecond fundamental propoſition of the theory of ſalts, namely, “that “the vitriolic acid is compounded of only the aqueous and earthy principles,” is, like the firſt, ſupported by many facts which give it a degree of probability, but which do not amount to a compleat demonſtration. This propoſition may be ſupported by the following conſiderations.

Firſt, experience conſtantly ſhews, that the properties of compound bodies are always the reſult of thoſe of the component parts of theſe bodies, or rather they are the properties of theſe component bodies modified by one another.

Thus, if a body be compoſed of two principles, one of which is fixed and the other volatile, it will have a leſs degree of fixity than the former, and a leſs volatility than the latter. If it be compoſed of two principles, one of which is ſpecifically heavier than the other, its ſpecific gravity will be greater than that of one of them, and leſs than that of the other. The ſame obſervation is applicable to all the other eſſential properties, excepting thoſe which deſtroy each other, as, for inſtance, the tendency to combination, or the diſſolving power; for theſe latter properties are weakened ſo much more in the compounds, as their principles are more ſtrongly united, and in more juſt proportion.

We obſerve nevertheleſs, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts muſt be equal, which is the caſe in few or no compounds.

Beſides, ſome particular circumſtances in the manner in which the principles unite with one another, contribute more or leſs to alter the reſult of the combined properties; for inſtance, experience ſhews, that when ſeveral bodies, particularly metals, are united together, the ſpecific gravities of which are well known, the allay formed by ſuch union has not the preciſe ſpecific gravity which ought to reſult from the proportion of the allayed ſubſtances; but that in ſome allays it is greater, and in others leſs. But we are certain, on the other ſide, that theſe differences are too inconſiderable to prevent our diſtinguiſhing the properties of the principles in the compounds which they form, eſpecially when they have very different properties.

Theſe things being premiſed, when we examine well the properties of vitriolic acid, we ſhall eaſily find that they partake of the properties of the aqueous and of the earthy principles.

Firſt, when this acid is as pure as we can have it, it is like the pureſt water and the pureſt vitrifiable earths, free from color or ſmell, and perfectly tranſparent.

Secondly, although we cannot deprive the vitriolic acid of all the water ſuperabundant to its ſaline eſſence, and therefore its preciſe ſpecific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much leſs heavy than any earthy ſubſtance.

Thirdly, this acid is much leſs fixed than any pure earth, ſince, however well it may be concentrated, it may always be entirely diſtilled; for which purpoſe, a much ſtronger degree of heat is requiſite than for the diſtillation of pure water.

Fourthly, we do not know the degree of ſolidity of vitriolic acid, or the *adheſion of aggregation* which its integrant parts have one to another, becauſe for this purpoſe the vitriolic acid ought to be deprived of all ſuperabundant water; but if we judge of it by the ſolid conſiſtence of this acid when highly concentrated, as we ſee from the vitriolic acid called *glacial*, the integrant parts of this acid ſeem ſuſceptible of a much ſtronger adheſion than thoſe of pure water, but much leſs than thoſe of earth, as we ſee from the inſtance of hard ſtones.

Fifthly, the union which this acid contracts with water and with earths ſhews that theſe ſubſtances enter into its compoſition: for we know that in general compounds are diſpoſed to unite ſuperabundantly with the principles which compoſe them. All theſe properties of vitriolic acid, which ſo ſenſibly partake, and much more than any other acid, of the properties of earth and of water, are ſufficient to induce us to believe that it is compoſed of theſe two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corroſive taſte. This property is ſufficient to raiſe doubts, if we could not explain it from principles which ſeem certain and general, relating to the combination of bodies. We ſhall here ſummarily recapitulate them, although we have ſpoken of them in ſeveral articles of this work, particularly at the words AFFINITY, AGGREGATION, SOLUTION, COMPOSITION, GRAVITY, SATURATION.

We obſerve then concerning the property now in queſtion, that is, of taſte in general, that it can only be conſidered as an irritation made upon the organs of taſte by ſapid bodies: and if we reflect attentively upon it, we ſhall be convinced that no ſubſtance that is not impreſſed by ſome impulſe, can irritate or agitate our ſenſible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their diſſolving power. According to this notion, the taſte of bodies, or the impreſſion made upon our ſenſible organs by their tendency to combination, or by their diſſolving power, are the ſame property; and we ſee accordingly, that every ſolvent has a taſte which is ſo much more ſtrong, as its diſſolving power is greater; that thoſe whoſe taſte is ſo violent that it amounts to acrimony, corroſion, and cauſticity, when applied to any other of the ſenſible parts of our body beſides the organs of taſte, excite in them itching and pain.

This being premiſed, the queſtion is, how earth, in which we perceive no taſte nor diſſolving power, and water, which has but a very weak diſſolving power, and little or no taſte, ſhould form by their combination a ſubſtance, ſuch as the vitriolic acid is, powerfully corroſive and ſolvent?

To conceive this, let us conſider firſt that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very ſmall molecules, or the integrant and conſtituent parts of bodies, ſeems proportionable to the denſity or ſpecific gravity of theſe parts. Thirdly, that this ſame force is limited in every integrant molecule of matter; that if we conſider this force as not ſatisfied, and conſequently as a ſimple tendency to combination, it is the greateſt poſſible in an integrant molecule of matter perfectly inſulated, or attached to nothing, and is the ſmalleſt poſſible, or none, when it is ſatisfied by its intimate combination with other parts capable of exhauſting all its action; its tendency is then changed into adheſion.

Hence we may infer, that the integrant parts of the earthy principle have eſſentially, and, like all the other parts of matter, a force of tendency to union, or of coheſion in union, according to their condition; that as this earthy principle has a much more conſiderable denſity or ſpecific gravity than all other ſimple bodies that we know, we may probably preſume that its primary integrant molecules have a more conſiderable force of tendency to union, in the ſame proportion, than the integrant parts of other principles; that conſequently when they cohere together, and form an aggregate, their aggregation muſt alſo be ſtronger and firmer than that of any other body. Accordingly we ſee that the pureſt earthy ſubſtances, whoſe parts are united and form maſſes, ſuch as, for inſtance, the ſtones called vitrifiable, are the hardeſt bodies in nature. We are no leſs certain, that as the tendency of the parts of matter to unite is ſo much leſs evident as it is more exhauſted and ſatisfied in the aggregation, the parts of the earthy principle being capable of exhauſting mutually all their tendency to union, we may thence infer, that every ſenſible maſs of pure earthy matter muſt appear deprived of any diſſolving power, of taſte, in a word, of tendency to union, from the firmneſs of its aggregation. But we may alſo infer, that when theſe primary integrant parts of the earthy principle are not united together in aggregation, then, reſuming all the activity and tendency to union which are eſſential to them, they muſt be the ſtrongeſt and moſt powerful of all ſolvents.

Theſe being premiſed, if we ſuppoſe again, with Stahl and the beſt chemiſts, that in the combination of the ſaline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then eaſily conceive that the primary integrant parts of the water, having eſſentially much leſs tendency to combination than thoſe of earth, the tendency of theſe latter to union will not be exhauſted, but ſatisfied only partly, by their combination with the former, and that conſequently a compound muſt reſult, the integrant parts of which will have a ſtrong diſſolving power, as vitriolic acid is.

We may ſee from hence how much miſtaken chemiſts are, who, conſidering earth only in its aggregation, or rather not attending to this ſtate, and not diſtinguiſhing it from that ſtate in which the parts of this ſame earth are ſo ſeparated from each other by the interpoſition of another body, that they cannot touch or cohere together, have conſidered the earthy principle as a ſubſtance without force or action, and have very improperly called that a *paſſive principle*, which of all others is the ſtrongeſt, moſt active, and moſt powerful.

However this general theory of ſalts may conform with the moſt important phenomena of chemiſtry, we muſt acknowledge that it can only be propoſed as a ſyſtematical opinion, till it be evidently demonſtrated by the deciſive means employed in chemical demonſtrations, namely, by decompoſition and recompoſition: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together theſe two principles, this theory would ceaſe to be a ſyſtem, and would become a demonſtrated truth. But we muſt confeſs that this theory is leſs ſupported by experiment than by argument, from the many difficulties that are inevitable in ſuch inquiries. For on one ſide, we know that the ſimpler bodies are, the more difficult is their decompoſition; and on the other ſide, the ſtronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very ſimple, ſince it is a compound of the firſt order, it ought ſtrongly to reſiſt decompoſition; and as the aggregation of pure earth is the firmeſt that we know, it cannot eaſily be made to enter as a principle into a new combination with water to form a ſaline matter. The following are the principal experiments which have been made relative to this ſubject.

Firſt, we ſeem to be certain, from many proofs, that all ſaline ſubſtances, comprehending thoſe that contain vitriolic acid, as vitriolated tartar, Glauber's ſalt, and other vitriolic ſalts which are ſufficiently fixed to ſupport a perfect drying, or rather calcination, being alternately diſſolved, dried, and calcined a number of times, are more and more diminiſhed in quantity, and that earth and water are ſeparated from them each operation. But alkaline ſalts appear to be ſtill more ſuſceptible than any other ſaline matter of this kind of decompoſition.

Secondly, when nitre is burnt in cloſe veſſels, ſo that we may retain not only all that remains fixed after this burning, but alſo what exhales in vapors, as in the experiment of the clyſſus of nitre, we have a proof which ſeems deciſive, that the mineral acid of this ſalt, which is not very far from the ſimplicity of vitriolic acid, is totally decompoſed and reduced into earth and water. For if we examine the fixed reſiduum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a ſuperabundant earth, which is ſeparable from it by ſolution and filtration. And if the liquor in the receiver, formed by the vapors condenſed there, be examined, which ought to be nitrous acid, if this acid had not been deſtroyed, we find that, ſo far from being acid, it is only pure water, ſometimes even charged with a little fixed alkali, which had been raiſed by the force of the detonation. Thus nitrous acid is made to diſappear in this experiment, and in its place we find only earth and water. *See* ACID (NITROUS), CLYSSUS *of* NITRE, DETONATION *of* NITRE, *and* NITRE.

Thirdly, the phenomena of limeſtone, which by calcination and extinction in water acquires ſaline properties that it had not before, its attenuation by fire, and its combination with water; and alſo the experiment of Beccher, who aſſerts, that if a vitrifiable ſtone be alternately made red-hot and extinguiſhed in water a number of times, it may be ſo attenuated, that it ſhall be like a ſaline gelatinous matter; theſe, I ſay, ſhew that ſaline matters are actually formed by the intimate combination of the very attenuated parts of earth with thoſe of water. We find in the writings of Beccher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other obſervations and experiments tending to prove the ſame propoſition; but we muſt confeſs that none of the experiments we have mentioned, excepting that of the decompoſition of nitrous acid by burning, are abſolutely deciſive, principally becauſe they have not been ſufficiently repeated, or proſecuted, nor carefully enough examined in all their circumſtances.

Such is the actual ſtate of the beſt theory of ſaline ſubſtances hitherto given. However fine and probable it may ſeem, it requires to be further illuſtrated, and better proved, eſpecially by experiments. They who love inquiries into the ſublimeſt parts of chemiſtry cannot engage in a more intereſting ſubject.

As ſubſtances eſſentially ſaline, and particularly thoſe of their combinations which are called *ſalts*, are very numerous, we ſhall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of theſe ſaline matters. We ſhall ſee by this kind of view, that although many combinations are known, many alſo are not known, becauſe they have never been made; and many others are known but imperfectly, becauſe they have not been ſufficiently examined.

Subſtances eſſentially ſaline are, acids, alkalis, and neutral ſalts with baſis of alkali.

The ſimpleſt and ſtrongeſt acids, called *mineral acids*, are, *vitriolic acid*, called alſo *univerſal acid*, or *ſaline principle*:

Nitrous acid, commonly called *ſpirit of nitre* or *aqua fortis*:

Marine acid, called alſo *ſpirit of ſalt*, and *acid of common ſalt*. See *all theſe articles*.

The acids leſs ſimple and leſs ſtrong than the mineral acids are thoſe which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or leſs attenuated. Theſe are cryſtallized eſſential acid ſalts, ſuch as *tartar*, called *cream* or *cryſtals of tartar*, when it is purified. *See* TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itſelf not only oily, but alſo ſpiritous. *See* VINEGAR.

The *unfermented acids of ſharp fruits and plants*, as the juice of *gooſeberries*, *citrons*, *ſorrel*, &c. Theſe acids have not been examined.

The acids and acid ſpirit, obtained in the diſtillation of vegetables, of their extracts, eſſential ſalts, oils, balſams, and reſins. As all theſe acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The *acids obtained from animal ſubſtances* are;

The acid obtained in the diſtillation of *ants*, *flies*, and other *inſects*; and the acid obtained in the diſtillation of *butter* or of *fat*. Theſe acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. *See* BUTTER *and* FAT.

Phoſphoric acid, the origin and nature of which are not ſo well known that we can determine to what kingdom it belongs. *See* PHOSPHORUS *of* KUNCKEL, *and* SALT (FUSIBLE) *of* URINE.

Alkalis or *ſaline alkaline ſubſtances* are,

The fixed alkali of common ſalt, called alſo *mineral* or *foſſil alkali*, *marine alkali*, *cryſtals and ſalt of ſoda*, becauſe it is obtained by lixiviation and cryſtallization, from the aſhes called *ſoda*.

Vegetable, or *common fixed alkali*. It is often called ſalt of tartar, or alkali of tartar, in the works of chemiſts, becauſe the aſhes of tartar furniſh the largeſt quantity of it. Both theſe fixed alkalis are called *cauſtic fixed alkalis*, when they have been altered by quicklime, or by metallic calxes. *See* ALKALI (FIXED).

Volatile alkali. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, ſo that it afterwards cannot be obtained in a ſolid or concrete form. *See* ALKALI (VOLATILE).

NEUTRAL SALTS.

Formerly thoſe only were called neutral ſalts which were compoſed of acids and alkalis united together to the point of ſaturation, ſo that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all ſubſtances with which they can ſo unite, that they loſe entirely, or moſtly, their acid qualities, as, for inſtance, when they are united with earthy or metallic ſubſtances. We ſhall enumerate theſe neutral ſalts, obſerving the order of the acids already enumerated.

VITRIOLIC SALTS.

Vitriolic acid, combined with marine alkali, forms a ſalt known by the name of *Glauber's ſalt*, or *ſal mirabile*, [illegible]

With fixed vegetable alkali it forms a ſalt called *vitriolated tartar*, *ſal de duobus*, and *arcanum duplicatum*. *See theſe names.*

With volatile alkali, it forms an ammoniacal ſalt, called *vitriolic ammoniacal ſalt*, and *ſecret ſal ammoniac of Glauber*. *See* AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic ſalts with baſis of calcareous earth*, known by the general name of *ſelenites*. *See that word.*

With argillaceous earth, it forms a *vitriolic ſalt with baſis of argillaceous earth*, called *alum*. *See* ALUM.

With metallic ſubſtances, it forms different *vitriolic ſalts with metallic baſes*, to which we ought to give the general name of *vitriol*, together with the name of the particular metal ſubjoined. Thus;

With gold, a ſalt little or not known, which may be called *vitriol of gold*.

With ſilver, a ſalt but little known, *vitriol of ſilver*.

With copper, a ſalt known by the name of *vitriol of copper*, or *blue vitriol*.

Vitriols are in commerce more generally called *copperas*. Accordingly, this is called *blue copperas*. It is alſo ſometimes named *cyprian vitriol*.

The ſame acid with iron forms *vitriol of iron*, called *green* or *martial vitriol*, or *green copperas*.

With tin, it forms a ſalt little known, a *vitriol of tin*.

With lead, a ſalt little known, a *vitriol of lead*.

With quickſilver or mercury, a ſalt not yet well known, a *vitriol of mercury*.

With regulus of antimony, a ſalt little known, a *vitriol of regulus of antimony*.

With biſmuth, a ſalt little known, a *vitriol of biſmuth*.

With zinc and calx or flowers of zinc, a *vitriol of zinc*, known by the name of *white vitriol*, *white copperas*, *vitriol of Goſlar*.

With regulus of cobalt, a *vitriol of cobalt*, very little known. Mr. Beaumé has begun to examine it.

With regulus of arſenic and arſenic, a *vitriol of arſenic*, or *arſenical vitriol*, very little known. *See the articles* ACID (VITRIOLIC) *and* VITRIOL, *and thoſe of the ſaline alkalis, earths, and metallic ſubſtances.*

NITROUS SALTS.

Nitrous acid, combined with all the ſubſtances of which we have juſt mentioned the combinations with vitriolic acid, forms ſalts to which we may give the general names of *nitre* or *nitrous ſalts*, ſpecifying each ſalt by the name of the ſubſtance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *ſaltpetre*.

With marine alkali it forms *cubic* or *quadrangular nitre*.

With volatile alkali, *nitrous ammoniacal ſalt*, or *ammoniacal nitre*.

With calcareous earth, *nitre with baſis of calcareous earth*,

With argillaceous earth, *nitre with baſis of argillaceous earth*, a kind of [illegible]

[illegible] *metallic nitres*.

With gold, [illegible] unknown.

With ſilver, [illegible] *lunar nitre*, *lunar cryſtals*, or *cryſtals of ſilver*.

With copper, *nitre of copper*, or *cupreous nitre*.
With iron, *nitre of iron*, or *martial nitre*.
With tin, *nitre of tin*, unknown.
With lead, *nitre of lead*, or *cryſtals of lead*.
With mercury, *nitre of mercury*, *mercurial nitre*, *cryſtals of mercury*.
With regulus of antimony, *nitre of antimony*, unknown.
With biſmuth, *nitre of biſmuth*, *cryſtals of biſmuth*.
With zinc, its calx and flowers, *nitre of zinc*, unknown.
With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.
With arſenic and its regulus, *nitre of arſenic*, or *arſenical nitre*, very little known. *See* NITRES (METALLIC), *or with* METALLIC BASES. *See alſo the articles* ACID (NITROUS), *the articles of all the ſubſtances we have mentioned, and thoſe of the nitrous ſalts which have particular names.*

MARINE SALTS, *or ſimply*, SALTS.

Marine acid forms with all theſe ſubſtances ſalts which may be called by the general name of *marine ſalts*, or ſimply *ſalts*, and ſpecified by the names of their particular baſes. Thus,

With marine alkali, it forms *common ſalt*, *kitchen ſalt*, *ſea-ſalt*, when extracted from the ſea, and *ſal gem* when dug from the earth.

With fixed vegetable alkali, *common ſalt with baſis of vegetable alkali*, called *febrifugal ſalt of Sylvius* improperly, becauſe it is no more febrifugal than any other; and ſtill more improperly called *regenerated ſea-ſalt*, becauſe it differs eſſentially from ſea-ſalt by the nature of its baſis.

With volatile alkali, it forms *ſal ammoniac*, formerly *armoniac*, and by ſome chemiſts called *ſalmiac*.

With calcareous earths, a *ſalt with baſis of calcareous earth*. As this ſalt is obtained in the decompoſition of ſal ammoniac by means of quicklime, or other calcareous earths, chemiſts have improperly called the ſalt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *ſalt with baſis of argillaceous earth*, very little or not known.

With metallic ſubſtances, it forms *ſalts with metallic baſes*, ſpecified by the name of each baſe. Thus,

With gold, it forms a *ſalt of gold*, unknown.

With ſilver, it forms a *ſalt of ſilver*, known by the [illegible].

With copper, it forms a *ſalt of copper*, [illegible].

With iron, a *ſalt of iron*, or *martial ſalt*, [illegible].

With tin, a *ſalt of tin*. This combination, [illegible] acid with metallic matters, may be [illegible] metal in the acid: but it may be ſtill better made, by [illegible] aſſiſtance of heat, and by means of the metal intended to be [illegible] acid, a combination already made of [illegible] ſubſtance; which is always poſſible when the [illegible] greater than that of the metal already [illegible]

[illegible]

lizable ſalt of tin, by diſſolving this metal directly in marine acid in the uſual manner: this ſalt is but little known. The ſame combination is made by decompoſing corroſive ſublimate by means of tin, and by diſtillation. Thus we may obtain a combination of tin with marine acid, one part of which paſſes with exceſs of acid in form of a very ſmoking liquor, called *ſmoking ſpirit of Libavius*, and the other part which does not ſmoke, and which contains a larger proportion of tin, is ſublimed in a ſolid ſtate, and is called *butter of tin*.

With lead, *ſalt of lead*, known alſo by the name *plumbum corneum*.

With mercury, *ſalt of mercury*. It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is ſeparated from the nitrous acid by means of marine acid; *mercury corroſive ſublimate*, or ſimply, *corroſive ſublimate*, when it is actually ſublimed, and with ſuch proportions of mercury and acid, that a very corroſive ſalt reſults from them; *ſweet mercury*, *ſweet ſublimate*, and *aquila alba*, when ſublimed with an additional quantity of mercury by which its corroſive quality is blunted.

With regulus of antimony, it forms an *antimonial ſalt* by diſtillation. It is called *butter of antimony*.

With biſmuth, it forms a *ſalt of biſmuth*, not much examined.

With zinc, and its calx and flowers, a *ſalt of zinc*, little known.

With regulus of cobalt, a *ſalt of cobalt*, alſo little known.

With arſenic and its regulus, a *ſalt of arſenic* or *butter of arſenic*, little known.

We may obſerve concerning all theſe combinations of marine acid with metallic matters, that as this acid is very volatile, and as it is capable of adhering ſtrongly with theſe ſubſtances, it does accordingly carry along with it more or leſs of them in ſublimations and diſtillations; which is the reaſon that theſe ſalts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by ſolution, or by diſtillation and ſublimation, as we ſee from the phenomena exhibited by corneous metals, as tin and regulus of antimony. Although chemiſts, and ſtill more, alchemiſts, have operated much on certain combinations of metallic ſubſtances with marine acid, much yet remains to be done to illuſtrate this ſubject.

We may here obſerve, that aqua regia, compoſed of nitrous and marine acids, which is in general a good ſolvent of metallic matters, muſt form with many of them mixed ſalts, ſome of which are perhaps of peculiar natures; but theſe combinations do not ſeem to have been examined hitherto as ſalts, no more than many others, as we may eaſily ſee from the preſent enumeration. *See the article* ACID (MARINE) *and of the ſeveral ſubſtances with which we have mentioned its combinations.*

TARTAREOUS SALTS.

We [illegible] name the combinations of the acid of tartar, or of [illegible] is, with the ſeveral ſubſtances [illegible] acids. [illegible] few of theſe ſalts are known, [illegible] in general called *ſoluble tartars*, becauſe they are all more ſoluble in water than the acid of tartar itſelf.

The combination of cream of tartar with fixed vegetable alkali forms a neutral cryſtallizable ſalt, called *ſoluble tartar*, *tartariſed tartar*, and *vegetable ſalt*. *See this latter word.*

With marine alkali, it forms the ſalt known by the name of *ſalt of Seignette*, *ſal polychreſt*, *ſalt of Rochelle*.

With volatile alkali, a *ſoluble ammoniac tartar*, unknown.

With calcareous earths, *ſoluble tartars with baſis of calcareous earth*, very little known, but which appear ſimilar to the *ſoluble tartars with baſis of fixed alkali*.

With argillaceous earths, *ſoluble tartars with baſis of argillaceous earth*, unknown.

With metals, *ſoluble tartars with metallic baſes*, *ſoluble tartars of gold*, *of ſilver*, &c. which are all unknown, excepting the ſoluble tartars with baſis of *iron* and of *glaſs of antimony*. The former is deliqueſcent, and called, when liquid, *tartariſed tincture of iron*, or *of Mars*, and when evaporated, *martial extract*. It ought to be called *ſoluble martial tartar*. *See* TARTAR (SOLUBLE), and *the other names here mentioned*. The ſecond ſoluble tartar with metallic baſis is called *emetic* or *ſtibiated tartar*. *See* TARTAR (EMETIC).

ACETOUS SALTS.

We ſhall give this name to all ſalts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliqueſcent ſalt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a cryſtallizable ſalt not much known, to which no name has been given. It may be called *acetous ſalt with baſis of marine alkali*.

With volatile alkali, an *acetous ammoniacal ſalt*, imperfectly known, and named *ſpirit of Mindererus*.

With calcareous earths, ſeveral *acetous ſalts with calcareous baſes*, very ſimilar one to another, and ſuſceptible of cryſtallizing, and forming beautiful *ſilky vegetations*, ſome of which are ſuperficially known, and named *ſalts of chalk*, *of crabs eyes*, *of coral*, &c.

With argillaceous earths, *an acetous argillaceous ſalt*, unknown.

With metallic ſubſtances, an *acetous ſalt with metallic baſis*, *of gold*, *ſilver*, &c. which are all unknown, excepting the three following:

With copper, an *acetous ſalt of copper*, known in chemiſtry by the names, *cryſtals of Venus*, or *of verdigriſe*, and in commerce and arts by the name *diſtilled*, or *cryſtallized verdigriſe*.

With lead, an *acetous ſalt of lead*, known by the name of *ſalt*, or *ſugar of lead*.

With mercury, an *acetous mercurial ſalt*, lately [illegible] known.

VEGETABLE SALTS.

This general name may be given to all neutral [illegible] and *juices*, *concrete ſalts*, [illegible] ſubſtances capable of uniting with theſe acids; but none of theſe ſalts are yet known.

VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the ſalts which might be formed with the acids obtained by the diſtillation of vegetable matters, which furniſh acid ſpirits or concrete acids, and which might be called *vegetable empyreumatic ſalts*.

ANIMAL EMPYREUMATIC SALTS.

By this name we may diſtinguiſh neutral ſalts compoſed with acids obtained from the diſtillation of animal matters, as the *acids of inſects*, *of butter*, and *of fat*; but all theſe ſalts are perfectly unknown.

Although we have given the epithet *empyreumatic* to ſalts formed with vegetable and animal acids, obtained by diſtillation of theſe ſubſtances with a heat greater than that of boiling water, we do not mean to imply, that theſe ſalts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to theſe acids after diſtillation. On the contrary, theſe acids may be deprived entirely or partly of this oil by paſſing into combinations of neutral ſalts, as happens to volatile alkalis when transformed into ammoniacal ſalts; but in this caſe we ſhould be better able to examine the nature of theſe acids, and the epithet empyreumatic would only refer to the manner of obtaining them, and would ſerve to diſtinguiſh them from thoſe vegetable or animal ſalts, the acids of which have been obtained without diſtillation in a naked fire.

PHOSPHORIC SALTS.

By this general name we mean all ſalts produced by combining the acid of *phoſphorus of urine* with alkaline, earthy, and metallic ſubſtances, a ſmall part of which ſales is known even imperfectly.

With fixed vegetable alkali, this acid forms a *phoſphoric ſalt*, a kind of *fuſible ſalt of urine*.

With marine alkali, it forms another *phoſphoric ſalt*, or *fuſible ſalt of urine with baſis of marine alkali*. It is well known.

With volatile alkali, a *phoſphoric ammoniacal ſalt*, called alſo *fuſible ſalt of urine, ammoniacal ſalt of urine, microcoſmic ſalt*.

With calcareous and argillaceous earths, *phoſphoric, calcareous, and argillaceous ſalts*, not known.

With metallic ſubſtances, *phoſphoric metallic ſalts of gold, ſilver, copper, &c.* very little known. See the article PHOSPHORUS.

Beſides theſe ſaline ſubſtances which have ſenſible acid properties, ſome ſubſtances, as ſedative ſalt and arſenic, without having theſe properties, do

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nevertheleſs act as acids in their combinations with all ſubſtances capable of uniting with true acids, of forming with theſe ſubſtances kinds of neutral ſalts, and even of communicating, like the acids properly ſo called, ſaline properties to thoſe ſubſtances which have them not. Theſe combinations are by general conſent claſſed amongſt neutral ſalts.

BORAX, *or* SALTS *of* BORAX.

The ſedative ſalt, combined with marine alkali, forms *ordinary borax.*

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic baſes of gold, ſilver*, &c. unknown.

ARSENICAL SALTS.

Arſenic forms, with fixed vegetable alkali, a neutral ſalt perfectly ſoluble in water, and cryſtallizable, called by Mr. Macquer, who firſt obſerved it, *neutral arſenical ſalt*, or ſimply *arſenical ſalt. See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

With marine alkali, another arſenical ſalt, very like the former, but not much examined.

With volatile alkali, an *arſenical ammoniacal ſalt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arſenical ſalt*, unknown.

With metallic ſubſtances, arſenic is perhaps capable of forming *arſenical ſalts with metallic baſes*, or combinations in which ſaline properties would be perceptible, if theſe combinations were made by decompoſing nitrous ſalts with metallic baſes by means of arſenic, or by precipitating metals diſſolved in acids by means of a ſolution of neutral arſenical ſalt in water; but perhaps from thence nothing would be produced but combinations ſimilar to the arſenical minerals. We are quite ignorant upon this ſubject.

Saline alkaline ſubſtances, beſides the ſalts which they can form with acids, can alſo act upon earths and metals, with which they form ſaline compounds, and from which, when ſeparated, they appear as before. Accordingly, theſe compounds may for this reaſon be ranked amongſt ſalts, and general and particular denominations may be aſſigned to them, according to the principles which compoſe them, as, for example, [illegible] *argillaceous*, *vitreous*, *metallic*, as of *gold*, *ſilver*, [illegible] conſidered them in this view, and have [illegible]

Laſtly, acids, alkalis, and even [illegible] neutral ſalts [illegible] oily ſubſtances, form compounds [illegible] may be conſidered [illegible] name be given, as it ought to be, [illegible] water: but theſe compounds form in ſome meaſure [illegible] diſtinguiſhed by the name of *ſoap*. [illegible]

From this enumeration of ſaline compounds we may ſee how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extenſive part of chemiſtry are nevertheleſs very neceſſary, and are fundamental and elementary. To make them ſucceſsfully, nothing is requiſite but accuracy, patience, and knowledge of the firſt principles of chemiſtry. Every intelligent perſon is capable of making them. For this purpoſe the acids, alkalis, earths and metals employed muſt be very pure, the ſaline compounds reſulting from their union muſt be examined; their taſte, ſolubility in water, cryſtallization, deliqueſcence, and the methods of decompoſing them muſt be obſerved. Theſe conſiderations are certainly ſufficient to excite the zeal of perſons who would contribute to the progreſs of chemiſtry.

We now proceed to treat ſummarily of the principal ſalts known by the name of ſalts, in an alphabetical order.

ACID SALTS.

Some chemiſts, and particularly ancient chemiſts, have thus named the ſaline ſubſtances which we only call *acids*. *See* Acids. We may however continue this name, and apply it to ſome concrete ſaline ſubſtances, as *tartar*, ſalt of *ſorrel*, &c. and to ſeveral other eſſential ſalts, which ſeem to be intermediate betwixt the ſtate of pure acids and of neutral ſalts.

SALTS *with* BASES ALKALINE, EARTHY *and* METALLIC.

By theſe general denominations the ſeveral neutral ſalts are diſtinguiſhed according to the nature of the baſis, or ſubſtance with which the acid is combined. *See the above enumeration of ſalts. See alſo the article* Neutral Salts.

SALT ALEMBROTH.

This is a ſaline matter, compoſed of *corroſive ſublimate* and of *ſal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemiſts, eſpecially the alchemiſts, have much employed as a powerful ſolvent of metals, and even of gold. We are certain that corroſive ſublimate and ſal ammoniac act powerfully one upon another, and combine together without being decompoſed, from which is formed a ſaline compound of a ſingular nature, capable of acting very effectually upon metallic ſubſtances. But the alchemiſts, who made ſo much uſe of this famous ſolvent, were far from underſtanding clearly the operations in which they employed it. As alchemiſts loved pompous names, they called this compound *ſalt of art*, *ſalt of wiſdom*, *ſalt of ſcience*.

ALKALINE SALTS.

This name is frequently given to ſaline alkaline ſubſtances, as *fixed alkalis, vegetable* and *mineral, volatile alkali. See theſe words.*

SALT *of* AMBER, *or* VOLATILE SALT *of* AMBER.

This is a ſaline, oily, concrete matter, obtained by ſublimation, or even by cryſtallization, from amber. It is a kind of eſſential ſalt, which forms ſhining needle-like cryſtals, has the ſmell of rectified oil of amber, and is ſoluble in ſpirit of wine. It is uſed only medicinally, as an antiſpaſmodic, with the ſame effect as the ſpirit and rectified oil of amber. *See* Bitumens *and* Salts (Essential).

AMMONIACAL SALTS.

By this name are diſtinguiſhed all neutral ſalts compoſed of any acid ſaturated with volatile alkali. *See* Ammoniacal Salts; *and* Salts (Neutral).

ARSENICAL SALTS.

See Salt (Neutral Arsenical).

COMMON SALT.

Common ſalt is a neutral perfect ſalt, compoſed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali.*

This ſalt, which is produced by nature, is more abundantly and univerſally diffuſed than any other. Immenſe mines or quarries of it are found within the earth, and it is then called *ſal gem* or *foſſile ſalt*. The waters of all the ſea, and many ſubterranean and mineral waters, contain it. From every vegetable or animal chemiſts can extract it.

The taſte of common ſalt is agreeable and moderately ſtrong. It is cryſtallizable, and is one of thoſe the figure of whoſe cryſtals is moſt regular, moſt determinate, and leaſt variable. The cryſtals of this ſalt are perfect, or nearly perfect cubes; for the hollow pyramids obtained in certain evaporations of ſalt waters are nothing but a heap of cubical cryſtals, arranged in this manner near each other, by means of evaporation.

Common ſalt is moderately ſoluble in water. Four parts of water are required to diſſolve one part of ſalt; and hot or boiling water diſſolves no more of it than cold water. For which reaſon it is only obtainable from ſea-water, and other waters impregnated with it, by a continued evaporation. *See* CRYSTALLIZATION.

Although common ſalt be very cryſtallizable, and exactly neutral, it very readily becomes moiſt when expoſed to humid air. It muſt be preſerved in very dry places.

This ſalt is ſuſceptible of contracting a certain union with *common ſalt with calcareous baſis*; for which reaſon all the ſalt obtained either from ſea-water or ſalt fountains always contains a certain quantity of this ſalt with earthy baſis. Thus, if any common ſalt be diſſolved in very pure water, and fixed alkali be added to this ſolution, we ſoon ſee the white earth of the ſalt with earthy baſis which is precipitated. As therefore cryſtallization ſeems inſufficient for the purification of common ſalt from the ſalt with earthy baſis, when we would obtain a very pure common ſalt, as is neceſſary for ſome delicate operations, we muſt diſſolve it in water, filtrate it, and add to it a ſolution of cryſtals of ſoda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we ſhall obtain a common ſalt perfectly pure. (*q*)

Common, ſalt expoſed to the action of fire, crackles and decrepitates pretty ſtrongly, when heated to a certain degree, eſpecially if it be heated haſtily. Its cryſtals burſt into ſmall pieces during this decrepitation. This effect is produced by the water of the cryſtallization of the ſalt, which being confined by the parts of the ſalt, and at the ſame time reduced into vapors by the action of fire, burſts the parts of the ſalt, and is diſſipated. Many chemiſts conſider this decrepitation of common ſalt as a property peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other ſalts, are ſuſceptible of a ſimilar decrepitation.

If ſalt be expoſed to a red-heat after this decrepitation, it fuſes; and when afterwards cooled, it fixes in form of a white and almoſt opake maſs; but excepting that it has loſt the water of its cryſtallization, it is the ſame as before this expoſure to fire.

Several chemiſts, having obſerved that when common ſalt is heated in a retort, a little marine acid exhales from it while it contains any moiſture, and that by adding more moiſture, more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this ſmall quantity of acid obtained by repeated humectations and diſtillations proceeded only from the common ſalt with earthy baſis, which, we have obſerved, is always mixed with common ſalt. From this

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(*q*) Sea-water contains diſſolved in it not only ſea-ſalt, or a combination of marine acid with mineral alkali, but alſo other ſalts, eſpecially combinations of marine and vitriolic acids with the earth called magneſia, which is not calcareous. See MAGNESIA, *and the New Notes*. Some of theſe ſalts, with baſis of magneſia, are cryſtallized along with the ſea-ſalt by the evaporation of the ſea-water, and part of them remains in the reſiduous liquor called the mother-water. Some portion of true calcareous earth, diſſolved by marine and vitriolic acids, is ſaid alſo to be contained in ſea-water; but the quantity of this is very ſmall in compariſon of the quantity of magneſia; to the precipitation of which, therefore, the cloud or turbid appearance given to ſea-water or to a ſolution of common ſalt in water, is chiefly owing.

earthy ſalt a portion of acid may actually be obtained by this method: but Mr. Beaumé has found, that no acid can be thus expelled from common ſalt perfectly purified in the above-mentioned manner.

This ſalt is abſolutely unalterable by fire, even when i has been heated ſtrongly, together with inflammable matters. The unalterable property of common ſalt by fire proceeds from the ſmall diſpoſition which its acid has to combine with phlogiſton. This truth has been demonſtrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this ſalt be fixed in the fire to a certain degree, yet when it is expoſed to a violent fire with free acceſs of air, it exhales in vapors, and attaches itſelf in white flowers to bodies which it finds leſs hot than itſelf. We have examples of this effect in certain fuſions of ores, where common ſalt is added; and in glaſs-houſe furnaces, where this ſalt, of which a certain quantity is contained in ſoda and potaſh, and which cannot enter into vitrification, attaches itſelf to the ſides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and ſedative ſalt, which can decompoſe common ſalt by diſengaging its acid: for arſenic, which ſo eaſily and effectually decompoſes nitre, cannot act upon this ſalt; a phenomenon, the cauſe of which deſerves to be examined, and which is certainly connected with an important theory.

Common ſalt is of all ſaline ſubſtances the moſt neceſſary, and extenſively uſeful. Beſides the particular uſes of its acid and alkali in many chemical operations and in arts; beſides its great utility in the fuſion of glaſs, which it whitens and purifies, although it does not enter, and perhaps becauſe it does not enter into their combination, as Mr. d'Antic has ſhewn; and from the property it has of facilitating the fuſion and precipitation of the metallic parts of minerals in eſſays, and of covering them perfectly; beſides theſe, I ſay, its great uſe in aliments, the taſte of which it improves by its agreeable piquancy, when mixed in proper quantity, is univerſally known. But this is not the only advantage; for it retards and prevents the putrefaction of almoſt all our aliments, without producing any ſuch change upon them, even when preſerved a long time by means of it, as to render them unfit for the purpoſe of nouriſhment. All other ſaline matters may indeed preſerve from putrefaction, as common ſalt does, and ſome of them even more effectually; but we do not know any other, the taſte of which renders it capable of being ſubſtituted to common ſalt for this purpoſe.

A very remarkable circumſtance in the antiſeptic property of common ſalt, and of ſome other ſalts, is, that this property varies ſurpriſingly according to the proportions in which the ſalt is employed; for this ſalt, mixed with animal matters in a large proportion, preſerves them from putrefaction, which it accelerates conſiderably when a ſmall quantity only of it is employed. This ſingular fact is proved by the experiments of Meſſrs. Pringle and Macbride, and particularly by thoſe of the accurate and intelligent author of *an Eſſay towards a Hiſtory of Putrefaction*, Mr. Gardane, Phyſician of the Faculty of Paris, who, having convinced himſelf of this fact by his own experiments, mentioned it in a very good theſis, and has drawn from it a concluſion which ſeems to me very juſt, namely, that ſmall quantities of common ſalt, ſuch as thoſe taken with aliments, facilitate digeſtion, which he conſiders as a beginning putrefaction. If this opinion be as true as it is probable and conſiſtent with the principles of chemiſtry, and of the animal economy, then common ſalt is not only agreeable and uſeful, but alſo ſalutary, at leaſt to all conſtitutions in which the digeſtion is too remote from putrefaction, as in thoſe which are properly called *crudities*: for we cannot but agree, that different temperaments differ much in this reſpect. *See the articles* ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER *of* SALT FOUNTAINS, SALTS, *and* SALTS (NEUTRAL).

CRYSTALLIZABLE SALTS.

By this name we diſtinguiſh all ſaline matters ſuſceptible of cryſtallization. It is contrary to that of *fluor ſalts*, by which are diſtinguiſhed ſaline ſubſtances that cannot be obtained in a cryſtallized concrete form, ſuch as nitrous and marine acids, volatile alkali altered by quicklime, and ſome others. We have nevertheleſs reaſon to believe, that, rigorouſly ſpeaking, every ſaline ſubſtance is eſſentially ſuſceptible of cryſtallization, and that in this reſpect they only differ in the degree of facility with which they may be cryſtallized; for we are certain that many very deliqueſcent ſalts, the cryſtallization of which has not, that I know of, been ever obſerved, ſuch as *common ſalt with calcareous baſis*, may nevertheleſs aſſume ſolid regular forms by the cooling of their ſolutions when very much concentrated. Mr. Beaumé has obſerved the cryſtallization of this and ſeveral ſimilar ſalts. *See* CRYSTALLISATION, DELIQUESCENCE, SALT, *and* SALTS (NEUTRAL).

SALTS *of* CENTAURY, *of* WORMWOOD, *of* SORREL, &c.

The name of *ſalt*, added to the proper name of ſome ſubſtance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the aſhes of vegetable matters. Salts of wormwood, centaury, &c. are ſaline matters obtained by lixiviating the aſhes of theſe plants: but theſe names are improper in ſeveral reſpects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is uſeleſs to diſtinguiſh them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is ſo predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names, *ſalt of tartar*, *ſalt of ſoda*, which are frequently given to the alkalis of theſe ſubſtances, are for the ſame reaſon very improper. They ought to be called *alkali of tartar* and *alkali of ſoda*.

Certain concrete acids, as the eſſential ſalt of ſorrel, tartar, &c. are alſo ſimply called *ſalt of ſorrel*, &c. This is alſo faulty, becauſe theſe names do not denote the nature of the ſaline matters, and may be the occaſion of confounding them with other ſalts of a very different nature. They ought to be named *eſſential ſalts*, or rather *concrete acids of ſorrel*, *of tartar*, &c.

The names *ſalts of coral*, *of pearls*, *of crabs eyes*, are not more accurat unleſs we add the epithet *acetous*, as *acetous ſalt of coral*, &c. for theſe ſubſtances may be combined, and may form ſalts with any other acid, as well a with vinegar.

Let us now judge if the names, *ſalt of quinquina*, *of ſena*, *of onions*, &c given to the dry extracts of theſe matters made in the manner of the Count d la Garaye, are not entirely improper. *See the preceding enumeration of ſalts.*

SALT *of* COLCOTHAR.

This is a white ſaline matter, obtained by lixiviating colcothar. This matte is not much uſed, and has not been much examined. It is probably ſom *ſelenitic* or *aluminous* ſubſtance, which is mixed with the vitriol, and which wa contained in the pyrites from which the vitriol was extracted.

SAL DE DUOBUS.

It is a neutral ſalt, formed by ſaturating vitriolic acid with the alkali of nitre *See* TARTAR (VITRIOLATED).

DELIQUESCENT SALTS.

Thus are named all ſaline matters which may be obtained by cryſtallization or drying in a concrete form, but which, when expoſed to air, imbibe its moiſture, and loſe their concrete cryſtallized form, deliquiating into a liquor by means of this moiſture. *See* DELIQUESCENCE.

SALTS *of* ENGLAND, *of* EPSOM, *of* SEDLITZ.

Some ſaline ſubſtances have been denominated from the countries where they have been firſt diſcovered. Thus a very rectified concrete volatile alkali, obtained from ſilk, is called *ſalt of England*; and even ſome druggiſts give this name to the concrete volatile alkali obtained from ſal ammoniac.

In a ſimilar manner, the name of Epſom ſalt is given to a badly cryſtallized, bitter Glauber's ſalt, which eaſily becomes moiſt, becauſe it is mixed with common ſalt, and common ſalt with calcareous baſis. It was firſt obtained from a ſalt well at Epſom near London. This name has been ſince given to a ſimilar Glauber's ſalt obtained from ſalt-marſhes in France, and alſo to a true and pure Glauber's ſalt obtained from the *ſchlot* of the ſalt-works of Lorraine and Franche-compté, the cryſtallization of which they diſturb purpoſely to prevent it from reſembling entirely the pure ſalt of Glauber.

Salt of Sedlitz is alſo a Glauber's ſalt under another name; and perhaps the ſame may be ſaid of many other ſalts denominated from places.

ESSEN-

ESSENTIAL SALTS.

This name is given to all concrete ſaline matters which preſerve the ſmell, taſte, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The uſual method of preparing them is by evaporating, to almoſt the conſiſtence of a ſyrup, the liquors containing the eſſential ſalt, namely, the expreſſed and depurated juices and ſtrong decoctions, and by keeping them in a cold place. From many of theſe liquors, ſaline matters or cryſtals are depoſited upon the ſides of the containing veſſels after a conſiderable time, and after they have undergone a kind of fermentation. Theſe cryſtals, which are always very red, may be purified by diſſolving them in water, filtrating, evaporating, and cryſtallizing.

We may obſerve, that the ſalts thus obtained from animal and vegetable matters are ſometimes nothing but vitriolated tartar, Glauber's ſalt, nitre, common ſalt, and other ſuch neutral ſalts, which ought not to be conſidered as the eſſential ſalts of the ſubſtances from which they are extracted.

Theſe mineral ſalts are extraneous to the vegetables and animals from which they are obtained. They are not parts of thoſe ſubſtances, nor are combined with them; and when they are purified from the extractive matter with which they are at firſt only mixed and covered over, they have then nothing vegetable or animal. Theſe ſalts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their veſſels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, becauſe they are naturally incapable of ſuch union.

The proof of this truth is, that they are always obtained from vegetables and animals in the ſame ſtate in which they were introduced, and that their quantity in theſe ſubſtances is altogether unconſtant and variable, without any real difference being produced in the vegetables or animals by this variation of the quantity of theſe ſalts. Certain plants, as the *parietaria*, but ſtill more the *corona ſolis*, have the property of imbibing ſo much nitre, that, when they grow in nitrous ſoils, they are almoſt filled with this ſalt. I have ſeen the dried pith of corona ſolis ſo full of cryſtallized nitre, that when ſhook over a paper, a conſiderable quantity of good deflagrating nitre might be collected. But we know alſo that this plant, when cultivated in a leſs nitrous ſoil, does not contain nearly the ſame quantity of nitre, although it be otherwiſe in good condition. Theſe mineral ſalts therefore muſt not be conſidered as the eſſential ſalts of plants or animals; and only thoſe ſalts are to be conſidered as ſuch, in the combination of which we find oily parts, which cannot be ſeparated from them, unleſs the ſalt be decompoſed.

In the ſecond place we ſhall obſerve, concerning ſalts truly called eſſential, that but very few of them are yet known, and moſt of theſe but very imperfectly. Of all theſe eſſential ſalts, the beſt known is tartar, the properties of which may be ſeen under the article TARTAR. The druggiſts have a very white concrete ſalt, well cryſtallized, and ſoluble in water, which they call *ſalt of ſorrel*. We may indeed obtain from the juice of ſorrel, by the above-mentioned proceſs, an eſſential acid concrete ſalt, but much more earthy and leſs acid that than the ſalt above-mentioned. Beſides, Mr. Beaumé, who has made ſome inquiries into this matter, affirms, that a true ſalt of ſorrel could not be procured at the price of the ſalt which is commonly ſold under that name, the quantity of ſalt obtainable from ſorrel being very ſmall. The ſalt above-mentioned is brought from Germany, is much more acid and more ſoluble in water than cream of tartar; it acts upon all ſubſtances ſoluble by acids; but the neutral ſalts thence formed have not been examined.

Flowers of benjamin, *volatile ſalt of amber*, and other ſaline matters of the ſame kind, ſeem to belong to this claſs of eſſential ſalts; but they are little known. Eſſential ſalts may be conſidered as a new ſubject of inquiry.

FIXED SALTS.

Many chemiſts give this name to the ſalts obtained from the aſhes of plants, which not having been diſſipated by fire, ought to be conſidered as fixed, in compariſon of the other ſaline matters of theſe plants, which evaporate during their deflagration.

As the ſaline ſubſtances remaining in the aſhes of vegetables are entirely or chiefly alkaline, the name of *fixed ſalt* has become ſynonimous with that of *fixed alkali*. But other ſaline ſubſtances, as moſt neutral ſalts, which have not baſes of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any ſaline matter is not perfect; ſince any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glaſs-houſes. A part of the fixed alkali, of the common ſalt, of Glauber's ſalt, of vitriolated tartar, and other equally fixed ſalts, contained in the aſhes uſed in the compoſition of glaſs, are perpetually exhaling, during the fuſion of glaſs, in a vapor which may be ſeen above the pots; and this vapor forms ſaline incruſtations round the openings and other leaſt hot places of the furnace. Accordingly, the quantity of ſalt of glaſs which covers the ſurface of the melted glaſs is continually diminiſhing. I have had occaſion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the ſame compoſition for cryſtal-glaſs, of which ſoda and pot-aſh made parts. The crucibles firſt taken out were covered with a cruſt of ſalt of glaſs more than two lines thick; thoſe taken out 18 or 20 hours afterwards had only a very thin ſtratum of glaſs-gall; and, laſtly, the crucibles which remained 72 hours in the fire, had no ſalt, or only a very ſmall quantity, upon the middle of the ſurface of glaſs.

Hence we ought to conclude that the quality of fixity aſcribed to ſome ſalts is only relative. We conſider thoſe as fixed, which ſuſtain a red heat during ſeveral hours, without any ſenſible diminution. Salts which by this red heat are reduced into vapors and ſublimed, are called *ſemi-volatile*, as the ammoniacal ſalts, and corroſive ſublimate; and laſtly, ſalts which are diſſipated without heat, or with very little heat, as the volatile acids and alkalis, are called *volatile ſalts*.

FLUOR SALTS.

This name is given to all ſaline ſubſtances which cannot by any method be rendered ſolid; ſuch are nitrous and marine acids, volatile alkali altered by quicklime, and ſome others. This quality depends on their volatility, and on the affinity which they have with water ſuperabundant to their ſaline eſſence. In this latter point they reſemble deliqueſcent ſalts, and they may even be conſidered as ſalts perpetually, and unſurmountably deliqueſcent. But they differ from ſalts that are only deliqueſcent, in this circumſtance, that theſe latter are much leſs volatile than the fluor ſalts, and can ſupport a heat ſufficient to deprive them of all their ſuperabundant water, and to reduce them to a concrete form. *See* DELIQUESCENCE *and* SALT.

FUSIBLE SALT *of* URINE.

This ſalt, called alſo *native* or *eſſential ſalt of urine*, *phoſphoric ſalt*, *microcoſmic ſalt*, is a neutral ſalt compoſed of an acid named *phoſphoric*, ſaturated with an alkali fixed or volatile; for both theſe kind of alkalis ſeem to be contained in urine.

To obtain this ſalt, urine freſh or putrid is to be evaporated to the conſiſtence of a ſyrup, ſlowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fuſible ſalt cryſtallizes on the ſides of the veſſel. When the ſalt ceaſes to form itſelf on the veſſel, the liquor is to be decanted, and again evaporated, that ſtill more cryſtals may be obtained by the ſame method. Theſe cryſtals are to be collected, which are very dirty and brown. They may be purified by diſſolving in pure water, filtrating, evaporating, and cryſtallizing, according to the general method. Theſe operations ought to be repeated when the ſalt is required to be very white and pure. Thus they are diſengaged not only from the extractive part of the urine which diſcolors them, but alſo from a portion of common ſalt which may be mixed with them, particularly when the urine has been much evaporated.

This ſalt is very ſuſceptible of cryſtallization, and is one of thoſe which are more apt to cryſtallize by cold, than by evaporation.

If this ſalt be expoſed to the action of fire in cloſe veſſels, a very pungent volatile alkali is expelled from it, which Mr. Schloſſer has obſerved to be always fluor, like that which has been altered by quicklime. This chemiſt affirms even that if concrete volatile alkali be combined with the fuſible ſalt of urine, and ſeparated from this ſalt by diſtillation, it will be in a fluor ſtate.

The acid of this ſalt is fixed, and remains at the bottom of the veſſels, melted to a vitreous matter, if the heat has been ſufficient for that purpoſe. This is the acid which produces the phoſphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteriſtic properties to the fuſible ſalt of urine. *See the properties of this acid under the article* PHOSPHORUS *of* KUNCKEL.

If this fuſible ſalt be mixed with the other fuſible ſalt with baſis of fixed alkali, as this latter ſalt cannot be decompoſed merely by diſtillation, nor even by means of phlogiſton, phoſphorus is therefore chiefly produced from the former, or the ammoniacal fuſible ſalt. *See* PHOSPHORUS *and* URINE.

FOSSIL SALTS.

Thus are called all the ſalts obtained ready formed within the earth; but more particularly common ſalt, which is coagulated in large maſſes within the earth, more frequently called *ſal gem*.

SAL GEM.

Sal gem is foſſil common ſalt, or which is found within the earth in large maſſes: It has ſome tranſparency, by which it reſembles cryſtal a little; and hence it has been called ſal gem. The moſt conſiderable mines of this ſalt are in Poland. Very curious and intereſting particulars concerning theſe mines may be ſeen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

SALT *of* GLASS.

This matter, called alſo *glaſs-gall*, is a kind of ſaline ſcum or maſs, found in glaſs-houſe pots upon the ſurface of the melted glaſs. It conſiſts of neutral ſalts, as common ſalt, vitriolated tartar, and others which are contained in the ſoda and potaſh employed in the compoſition of glaſs, and which not being themſelves ſuſceptible of vitrification, are ſeparated from the glaſs during the fuſion, and are collected together upon its ſurface, becauſe they are ſpecifically lighter. Hence we ſee, that as all the ſoda and potaſh employed for the compoſition of glaſs contain more or leſs of theſe extraneous neutral ſalts, the ſalt of glaſs muſt vary according to the ſaline ſubſtances employed. For the ſame reaſon no ſalt of glaſs is found where only pure and vitrifiable ſalts, as purified alkalis, nitre, borax, &c. are employed. *See* VITRIFICATION.

GLAUBER'S SALT.

The ſalt thus named, from the chemiſt who diſcovered it, is a neutral ſalt, compoſed of vitriolic acid ſaturated with marine alkali.

Glauber diſcovered this ſalt, while he was decompoſing common ſalt by means of vitriolic acid, to obtain the ſmoking marine acid by diſtillation. The reſiduum of this diſtillation he found to be a ſaline maſs, not cryſtallized, which he diſſolved in water, and obtained, by evaporation and cold, tranſparent cryſtals. Glauber, ſurpriſed with the appearance and properties of theſe cryſtals, gave them the name of *ſal mirabile*, by which they are ſtill known, but more generally by that of *Glauber's* ſalt.

This ſalt, although compoſed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter ſalt in many reſpects, which differences are to be attributed to the difference of the alkaline baſes, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taſte of Glauber's ſalt is ſaltiſh but diſagreable and bitter. It is one of the ſalts which form the fineſt cryſtals. When large quantities of this ſalt are cryſtallized, and with due attention, large, oblong, columnar cryſtals are formed, the ſurfaces of which are ſtriated longitudinally, like thoſe of nitre.

The cryſtals of this ſalt are as tranſparent as ice, but when expoſed to a dry air they loſe their tranſparency by the evaporation of the water of their cryſtallization. Their ſurface, and afterwards the whole of the ſaline maſs, is reduced by the diſſipation of this water to a white ſaline powder. This change alſo happens to the cryſtals of marine alkali, to which probably this property of Glauber's ſalt muſt be attributed.

The quantity of water which enters into the cryſtallization of Glauber's ſalt is very conſiderable, and amounts to nearly one half of its weight. To this large quantity of water is probably owing the ſize and tranſparency of the cryſtals: For it ſeems to be a general rule, that the more water is contained in any ſalt, the more large and tranſparent its cryſtals are. From this ſame abundance of water, Glauber's ſalt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and ſolid, and requires greater degree of heat to fuſe it.

This ſalt, although very ſoluble, even in cold water, is one of thoſe which may be diſſolved in a leſs quantity of boiling than of cold water. Hot water diſſolves nearly an equal weight of it. From this property we may know, that the cryſtallization of Glauber's ſalt is beſt procured by the cooling of a ſufficiently evaporated ſolution. Accordingly, a ſure method of obtaining the fineſt cryſtals of ſalt of Glauber is, to evaporate the water, in which it is diſſolved, till we find by taking out and trying a ſmall quantity of the ſolution while evaporating, that cryſtals are pretty quickly formed by cooling. It is then to be poured into flat and ſhallow veſſels, and cooled ſlowly. The larger the quantity of liquor is operated upon at a time, the larger will the cryſtals be; ſo that they may be obtained ſeveral feet long, and proportionably thick. Theſe cryſtals are placed horizontally upon each other, and the cryſtallization ought therefore to be performed in wide veſſels. *See* CRYSTALLIZATION.

Glauber's ſalt cannot be directly decompoſed but by means of phlogiſton only: For the decompoſitions made of it by metallic ſolutions are by means of a double affinity: and the decompoſition which may be effected by the nitrous acid alone, upon Glauber's ſalt and vitriolated tartar, as Mr. Beaumé diſcovered, is alſo cauſed by phlogiſton. (r)

(r) The ſingular decompoſition of vitriolated tartar, and of Glauber's ſalt, by means of nitrous acid, as mentioned by Mr. Beaumé, does not ſeem to be cauſed by the phlogiſton of the nitrous acid, as the author of the Dictionary believes; for Mr. Margraaf affirms, that theſe neutral ſalts, and alſo that nitre, may be decompoſed in a ſimilar manner by marine acid.

Glauber's ſalt is uſed only in Medicine. In ſmall doſes, as from one to two gros, it is reſolvent and aperitive, and as ſuch is added to ptiſans and apozems. It is alſo employed as an attenuant and corrective in the ſame doſe in purgative potions; and it is itſelf a good and mild purgative, as all the neutral ſalts are, the baſis of which are fixed alkali: The doſe of this ſalt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's ſalt, we need not combine the pure diſengaged vitriolic acid with the alkali of ſoda, nor decompoſe common ſalt by vitriolic acid, as Glauber did, unleſs we deſire to obtain at the ſame time the marine acid. Nature furniſhes a large quantity of this ſalt ready formed. A conſiderable quantity of it is contained in mineral waters, and perhaps all waters which contain common ſalt contain alſo ſome Glauber's ſalt. (*s*) The ſalt wells of Lorraine, of Franche-compté, of Epſom, contain much of it, and from theſe it may be eaſily obtained by cryſtallization. Further, from all vitriolic ſalts with earthy or metallic baſes, as ſelenites, alums, vitriols, Glauber's ſalt may be obtained by decompoſing them with ſoda. Laſtly, by burning ſulphur with common ſalt or ſoda, this ſalt may be formed. If it were much wanted, it might be eaſily and cheaply made by theſe proceſſes. *See the articles* ACID (VITRIOLIC), ALKALI (MARINE), CRYSTALLIZATION, WATER *of the* SEA, *and of* SALT FOUNTAINS, SALT, *and* NEUTRAL SALTS.

SALT *of* LEAD.

Thus is commonly called the neutral ſalt compoſed of the acid of vinegar ſaturated with lead. As this ſalt has a ſweet and ſaccharine taſte, it is called *ſugar of lead.*

To make this acetous ſalt, ceruſs, which is lead half diſſolved, and corroded by vinegar, is to be entirely diſſolved in diſtilled vinegar by means of heat in a ſand-bath; the liquor, when perfectly ſaturated, is to be evaporated, and cryſtallized by cooling, and many ſmall needle-like cryſtals will be formed in it, which are to be well drained.

This ſalt is not much uſed in medicine. It is uſed only externally, becauſe the lead is pernicious. It is employed in ſome arts, and eſpecially in dyeing, to heighten the red color of madder. *See* CERUSS, LEAD, *and* VINEGAR.

(*s*) Glauber's ſalt, that is, a ſalt formed by vitriolic acid combined with mineral alkali, is contained in ſea-water and in many mineral waters. But the *ſal catharticus amarus* of the London Diſpenſatory, extracted from the bitter liquor remaining after cryſtallization of ſea-ſalt in ſea-water, and the *ſalt of Epſom*, and of moſt purging waters, tho' very ſimilar in appearance to this true Glauber's ſalt, with which it is frequently confounded, is found to be compoſed of vitriolic acid united with the earth called magneſia. *See magneſia.* This ſa[illegible] ſiſts of priſmatic cryſtals like thoſe o[illegible] ber's ſalt, has a bitter taſte, is ſo[illegible] in leſs than an equal weight of wa[illegible] on expoſed to a moderate heat, it [illegible] li- quefies, and loſes the water of its cryſtallization, which amounts to more than half its weight; and is changed by this evaporation into a white powder, which is very ſoluble in water, by addition of which, together with evaporation, it may be reſtored to its former cryſtallized ſtate.

LIXIVIAL SALTS.

This is a general name given to all ſaline ſubſtances obtained by lixiviation of aſhes, but is particularly applied to fixed alkalis, becauſe the ſalts thus obtained from aſhes are altogether or moſtly alkaline. *See* ALKALI (FIXED).

NEUTRAL SALTS.

If this name be taken in its moſt extenſive ſenſe, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic ſubſtances. Theſe are ſalts formed with baſis of fixed alkali, vegetable or marine; with baſis of volatile alkali, called ammoniacal ſalts; or with baſes of calcareous and argillaceous earths; and, laſtly, thoſe with baſes of metallic ſubſtances. *See the above enumeration of ſalts.*

The name *neutral*, given to theſe ſalts, relates to the reciprocal ſaturation of their acids and their baſes. This ſaturation ought to be ſuch, that the properties of the two principles of the neutral ſalt ſhould be neither thoſe of a pure acid, nor of its pure baſis, but mixed or intermediate; and from hence theſe ſalts have alſo been called *intermediate ſalts*, or *ſales medii*.

The moſt important conſideration concerning theſe ſalts, is the juſt ſaturation of their two component principles. A neutral ſalt ought to be conſidered as perfect in its kind, when its acid and baſis are each of them in the moſt perfect relative ſaturation; that is, when the acid and the baſis are united together in as large quantity and as intimately as they can be, each according to its nature. But we muſt remark upon this ſubject, that a neutral ſalt may be perfect in its kind, and exactly ſaturated in the ſenſe we have mentioned, altho' its principles be very far from being completely or abſolutely ſaturated; that is, altho' they have not exhauſted upon each other all their tendency to combine. In this reſpect the neutral ſalts differ much; and on this chiefly depend the eſſential differences evidently obſervable in the taſte, ſolubility, cryſtallization, deliqueſcence, facility of decompoſition, and action upon other ſubſtances, of theſe neutral ſalts.

From a circumſtantial examination only of the properties of neutral ſalts, we can acquire any knowledge concerning them; but we are far from having ſufficiently examined them: for beſides that many ſaline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning thoſe ſalts which are beſt known. We need not therefore be ſurprized that we cannot yet eſtabliſh a good general theory concerning neutral ſalts. We ſhall here only mention ſome general principles which ſeem to reſult from what is already known, and which ſeem capable of leading us to further reſearches.

Firſt, the neutral ſalts reſulting from the union of acids in general with fixed alkalis, are more abſolutely ſaturated than thoſe with baſis of volatile alkali, and theſe more than ſalts with baſis of earth, excepting ſelenites; and, laſtly, the ſalts with baſis of earth are more abſolutely ſaturated than ſalts with metallic baſes. In the firſt claſs of theſe ſalts, namely, thoſe with baſis of fixed alkali, we find moſt of the ſalts which have the leaſt taſte, ſolubility, deliqueſcence, action upon other bodies, or facility of decompoſition, and the greateſt tendency to cryſtallization. On the contrary, in the laſt claſs, namely, the ſalts with metallic baſes, we find moſt of thoſe that are corroſive, moſt ſoluble, deliqueſcent, leaſt cryſtallizable, moſt active upon other ſubſtances, and moſt eaſily to be decompoſed. The two intermediate claſſes with baſes of volatile alkali, and of earth, are alſo intermediate with regard to theſe properties.

Secondly, as the ſeveral acids are more or leſs ſimple and powerful, they form with the ſubſtances to which they are capable of uniting, neutral ſalts, the abſolute ſaturation of which is more or leſs perfect, according to the nature of the acid. Neutral vitriolic ſalts are the firſt in this reſpect, then nitrous and marine ſalts, or marine and nitrous ſalts; for theſe acids do not differ much; and, laſtly acetous and tartareous ſalts.

We ought to obſerve upon this ſubject of general conſiderations upon neutral ſalts, that we muſt not judge, from one or a few of their properties, concerning the degree of coheſion and of abſolute ſaturation of their principles, but from all their properties taken and compared together; becauſe poſſibly one of the principles of a ſalt may be abſolutely, or almoſt abſolutely, ſaturated, while the other principle may be far from this degree of ſaturation; and according as the acid or the baſe is moſt ſaturated, the properties of the neutral ſalt muſt vary conſiderably. For example; we ſhould be much miſtaken, if, upon conſidering that corroſive ſublimate is leſs ſoluble in water than common ſalt, and not at all deliqueſcent, as the latter ſalt is a little, we ſhould conclude, that the coheſion of the principles of corroſive ſublimate and their abſolute ſaturation are much ſtronger than in common ſalt. The corroſive quality of this ſalt, and its powerful action upon many bodies, which properties do not, or ſcarcely, exiſt in common ſalt, evidently prove the contrary. *See* SUBLIMATE (CORROSIVE).

We muſt alſo obſerve, that in many combinations of neutral ſalts, and particularly of thoſe with metallic baſes, ſome metals and the acids themſelves ſuffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic ſalt reſulting from their union: for inſtance; although lunar and mercurial nitre be cryſtallizable, and little, if at all, deliqueſcent, while the nitres with baſes of copper and of iron are very much ſo, we muſt not thence conclude, that iron and copper ſaturate the nitrous acid leſs than ſilver and mercury do; becauſe we are certain that this difference does only proceed from this circumſtance, that while the nitrous acid diſſolves copper and iron, it decompoſes them, and deprives them of much of their inflammable principle which is neceſſary to the connexion of metals with acids, while it does not produce the ſame effect ſo evidently upon ſilver and mercury. Accordingly, the ſalts, which reſult from the ſolution of copper and of iron by nitrous acid, ought not to be rigorouſly conſidered as combinations of theſe metals, but rather as combinations of their earth with this acid; for as nitrous acid quits ſilver and mercury to diſſolve copper and iron, probably if this ſolution could be made without loſs of the phlogiſton of theſe latter metals, they would more compleatly ſaturate this acid, and more firmly adhere to it, than the former metals.

Many other conſiderations of this kind may be made concerning the different kinds of neutral ſalts; but the detail of them would engage us too long, beſides that they will eaſily occur to thoſe who would attentively reflect on this ſubject. We will however mention ſomething concerning a diſcuſſion that has ariſen lately betwixt ſome chemiſts relative to neutral ſalts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that ſeveral of theſe ſalts may be in two different ſtates; that is, they may be in a ſtate of a perfect ſaturation, or, they may have an exceſs of acid. He cites for examples ſeveral combinations of metallic matters with acids, ſuch as thoſe of mercury with marine acid and with vitriolic acid, and that of biſmuth with nitrous acid. Each of theſe metals may, according to him, form with the ſame acid two very different neutral ſalts, one of which has an exceſs of acid, and contains the largeſt poſſible quantity of acid; and the other is preciſely ſaturated, and contains the ſmalleſt quantity poſſible of acid. This chemiſt cites alſo, as another inſtance of the ſame doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming conſequently the neutral ſalt called *vitriolated tartar*. Mr. Beaumé has oppoſed this opinion in many Memoirs read at the Academy, and alſo in the Journal and Gazette of Medicine. He diſputes the facts upon which Mr. Roulle eſtabliſhes his theory. He maintains, that many of the ſaline metallic combinations cited by Mr. Rouelle as examples, and conſidered by him as neutral ſalts containing the leaſt poſſible quantity of acid, are nothing leſs than ſalts; but metals, deprived of all acid, when the acid which adheres ſuperficially to the precipitated metal is ſufficiently waſhed from it; and he thinks that Mr. Rouelle has been miſtaken, from not having ſufficiently waſhed theſe metallic precipitates, which he conſidered as ſalts. Mr. Beaumé proves his opinion, by waſhing with a very large quantity of diſtilled and boiling water turbith mineral and mercurius vitæ; which precipitates he, by this method, deprived of every particle of acid.

With reſpect to the vitriolated tartar, the proceſs by which Mr. Rouelle gives it an exceſs of acid is, by diſtilling in a retort two ounces of pure vitriolic acid upon this ſalt, till the ſalt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle obſerves, that when vitriolic acid is poured upon this ſalt, a conſiderable heat is excited, even when the ſalt has been deprived of the water of its cryſtallization by drying; and thence concludes, that the acid acts upon and combines with the ſalt. The ſaline maſs remaining after the diſtillation melts, and weighs, as Mr. Rouelle has obſerved, five ounces and one gros. This, according to him, is vitriolated tartar with exceſs of acid. He affirms alſo, that in this ſalt, as in all thoſe which are ſuſceptible of receiving exceſs of acid, there is a point of ſaturation of this exceſs of acid, and this point is marked in the preſent operation by the ceaſing of white vapors which riſe during the diſtillation. This vitriolated tartar with exceſs of acid has really an acid taſte, it attracts the moiſture of the air, reſolves in a liquor, like the deliqueſcent ſalts, reddens the tinctures of violets and of turnſol, efferveſces with fixed and volatile alkalis, and, laſtly, in cryſtallizing, remains acid.

Mr. Beaumé acknowledges almoſt all theſe facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an exceſs of combined acid. He ſupports his opinion upon the following facts and reaſons:

Vitriolic acid diſtilled from pure ſand, in the ſame manner as Mr. Rouelle diſtilled that acid from vitriolated tartar, adheres to it in the ſame manner, although we are certain that it does not act upon ſand. In this therefore, and in many caſes, it is only an adheſion of juxta-poſition, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, eſpecially when perfectly concentrated.

In the ſecond place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolated tartar is only ſuperficially covered, by Mr. Rouelle's proceſs, is ſo far from being truly combined, that it may be entirely ſeparated without fire, or any intermediate ſubſtances, by means purely mechanical: for by draining this ſalt very carefully upon brown paper, or even upon clean ſand, a vitriolated tartar perfectly neutral may be obtained, which preſerves the water of its cryſtallization, and conſequently the form and ſolidity of its cryſtals, and which no longer contains any veſtige of an acid. From theſe experiments Mr. Beaumé concludes, that this exceſs of acid in vitriolated tartar is not real, and is, like the unwaſhed metallic precipitates, miſtaken for ſalts with the leaſt poſſible quantity of acid, one of thoſe deceitful appearances againſt which we cannot too much guard. Mr. Beaumé generaliſes his propoſition concerning the exceſs of acid of vitriolated tartar, and affirms, that no neutral ſalt with baſis of fixed alkali either has an exceſs of combined acid, or of combined alkali, although it be cryſtallized in an acid or an alkaline liquor; and that the acid or alkali, with which theſe ſalts are mixed, when cryſtallized in ſuch liquors, is only interpoſed betwixt their parts, and may always be carefully ſeparated from them ſolely by the mechanical method of imbibition.

We ſhall not enter more particularly into theſe ſubjects, which perhaps will hereafter be further illuſtrated. We ſhall only obſerve, that if we were to examine theſe matters as well as they deſerve, it ſeems eſſential to diſtinguiſh firſt metallic ſalts from all others; for the greater or leſs degree of concentration of acids ſeems indifferent, with regard to the ſaline combinations which reſult from the union of theſe acids with earths and alkalis both fixed and volatile; that is to ſay, the ſame quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water; but metals, eſpecially ſome certain metals, cannot be combined, or remain combined with acids, in the greateſt poſſible quantity, unleſs the acid employed be in a proper degree of concentration; ſo that the ſame quantity of the ſame acid, which, when ſufficiently concentrated, is capable of remaining united with a certain quantity of metal, can diſſolve only a much leſs quantity of the ſame metal, if this quantity of acid be diluted with a larger quantity of water.

This ſingular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their compoſition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at leaſt much more by the former than by the latter: but on the other ſide, the union of water with any body is an obſtacle to the combination of that body with the inflammable principle. A quantity of acid therefore, diluted with water, cannot be united but with a leſs quantity of metal than the ſame quantity of acid when concentrated. This ſeems to be naturally deduced from the fundamental principles of chemiſtry.

In the ſecond place, we may remark, that after having diſtinguiſhed metallic ſalts from all others, we ought alſo to diſtinguiſh the combinations of mercury and marine acid, and even the corroſive metals, from all other metallic ſalts. Theſe ſalts make a diſtinct claſs, and have a peculiar character. *See upon this ſubject the article* Sublimate (Corrosive).

Notwithſtanding the diſtinctions we have ſhewn between the different kinds of neutral ſalts, we are far from believing that they can be methodically diſtributed, from conſidering any of their common properties, or claſſed, as plants have been by botaniſts; becauſe each of them has ſo many peculiar, and, at the ſame time, very eſſential, properties, that the ſalts in the ſame claſs would often differ more from each other in their peculiar properties than they would be ſimilar in their common property by which the claſs is characteriſed. A proof of this truth may be ſeen in a Memoir inſerted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to claſs neutral ſalts according to their cryſtallizations: for we find very different ſalts ranged not only in the ſame ſection, but alſo under the ſame genus, as, for inſtance, *ſal ammoniac*, and the *combination of lead with marine acid*. We do not mean to depreciate Mr. Rouelle's attempt upon this ſubject, or thoſe of others in the ſame way, as we are convinced, that however unſucceſsful theſe may be in their particular object, they muſt increaſe our knowledge by the many experiments and obſervations which they require, and by the compariſons and new views they occaſion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this.

Neutral ſalts have many uſes in chemiſtry, arts, and medicine; but as theſe uſes depend upon the peculiar nature of each of them, we refer to the particular articles; and here we ſhall only ſay a little concerning their medicinal virtues.

We may obſerve, that theſe ſalts are antiſeptic when mixed in a proper doſe, that is, in a large doſe, with ſubſtances capable of putrefaction. Each of them reſiſts all kinds of fermentation more or leſs effectually; but the moſt exact experiments that have been made on this ſubject by Sir John Pringle, by the author of the Eſſay on Putrefaction, and by Mr. Gardane, phyſician at Paris, prove that theſe neutral ſalts, the principles of which are firmly connected, as all thoſe with baſis of fixed alkali, particularly common ſalt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Eſſay on Putrefaction, that the moſt powerful antiſeptics among the neutral ſalts are thoſe which are moſt aſtringent, as the neutral ſalts with metallic baſes.

All neutral ſalts with baſis of fixed alkali taken internally in the doſe of an ounce or more, produce in general a very mild purgative effect; and in ſmall doſes, as of one or two gros, they are only aperitive.

Ammoniacal ſalts are given in ſmall doſes only. They are exciting, dividing, and [illegible]. The common ſal ammoniac is the only ammoniacal ſalt uſed.

Neutral ſalts with baſes of calcareous earths are alſo conſidered as aperitive [illegible], but they differ much according to the nature of their acids. [illegible] are very different in their effects from nitrous and marine ſalts with calcareous baſes. Of theſe ſalts, only the acetous, ſuch as the ſalts of coral, pearls, &c. are employed, and theſe but very little in France.

All the ſalts with metallic baſes are corroſive, eſpecially thoſe containing mineral acids. Accordingly, they are not internally employed in medicine, excepting ſome of thoſe with baſes of mercury, iron, regulus of antimony. *See the articles* IRON, MERCURY, REGULUS *of* ANTIMONY, *and* TARTAR (EMETIC).

NEUTRAL ARSENICAL SALT.

This ſalt is a combination of arſenic with fixed alkali to the point of ſaturation. Mr. Macquer firſt diſcovered this combination, and began an account of its properties in the Memoirs of the Academy for the years 1746 and 1748. His method of making this ſalt is, by mixing together equal parts of very white cryſtalline arſenic and purified nitre, and by diſtilling this mixture in a retort with a graduated heat in the uſual manner, till the retort is red-hot, and no more vapors of nitrous acid ariſe. In the retort a ſaline maſs remains, white, compact, and fixed; from which, after ſolution in hot water, filtration, evaporation, and cryſtallization, may be obtained beautiful, quadrangular, priſmatic cryſtals, terminated at each end by a quadrangular pyramid, the ſides of which correſpond with thoſe of the priſm.

Arſenic is known to have the property of decompoſing nitre, and of very eaſily diſengaging its acid; but, at the ſame time, it combines with the alkali of the ſalt, and ſaturates it preciſely as an acid would do; ſo that the new ſalt which reſults from this operation when well made, is exactly neutral, and gives no marks of an alkaline quality. It is infinitely more ſoluble in water than pure arſenic, and diſſolves in a leſs quantity of hot than of cold water.

This ſalt is eaſily fuſible by fire, and remains fuſed and tranſparent like glaſs, without being alkaliſed, if it has not touched any inflammable matter: for it may be eaſily decompoſed by phlogiſton which unites with the arſenic, ſeparates it from the alkali, and is ſublimed. No pure mineral acid can decompoſe this ſalt, becauſe arſenic ſeems to have a greater affinity with fixed alkali than acids have; but when theſe acids are united with metallic matters, they then eaſily decompoſe the neutral arſenical ſalt, even by the humid way; ſo that a ſolution of this ſalt added to a ſolution of metals occaſions a precipitate compoſed of the arſenic and metal, while the acid of the metallic ſolution combines with the fixed alkali of the neutral arſenical ſalt, and forms another neutral ſalt. Thus two decompoſitions are made, and two new combinations are formed.

The uſes of the neutral arſenical ſalt are not yet well determined; but as the arſenic ſeems, from the properties mentioned, to be ſtrictly united with the fixed alkali, this ſalt may probably be uſefully employed, 1. for the preparation of the regulus of arſenic; 2. to combine arſenic conveniently with metallic matters; 3. in the compoſition of many glaſſes; 4. as the corroſive mineral acids form very mild ſalts when ſaturated with alkalis, we may be induced to believe that arſenic [illegible] united with a fixed alkali as it is in the neutral arſenical ſalt, might form a [illegible] mild ſalt which [illegible] employed in medicine; but the name of arſenic is ſo terrible, that it will probably be never tried: but if it ſhould, very numerous and long trials ought to be previouſly made on animals.

This ſalt might probably be uſeful in arts; for Mr. Beaumé prepares large quantities of it for different manufactures; but the uſes to which it is applied are kept ſecret. *See* Arsenic.

SALT *of* MILK.

Salt of milk is a neutral ſalt of a ſingular nature, and very little known. It is obtained from whey by evaporation and cryſtallization. As the evaporated whey from which it is obtained has a red color and a ſaccharine taſte, that part of the ſalt of milk, which cryſtallizes firſt, has the ſame color and taſte; and hence it has been called *ſugar of milk*. If it be required more white and pure, it muſt be again diſſolved in pure water, and cryſtallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is leſs ſaccharine, and has in general leſs taſte; becauſe it is diſengaged from the ſaccharine part of the milk, and even from a little common ſalt, which may afterwards be ſeparated from the whey.

Cryſtals of this ſalt ſeem to contain very little water: they have little taſte, are not deliqueſcent, nor very ſoluble, and ſeem to be difficultly decompoſed. They deſerve a farther examination.

Some perſons have imagined, that a liquor like whey might be made by diſſolving ſalt of milk in pure water; but this ſalt is only one of the conſtituent parts of whey, and conſequently the purer it is, the leſs can its ſolution imitate that liquor. *See* Milk.

SAL POLYCHREST.

The word polychreſt is applicable to things which have many uſes: accordingly chemiſts ſay, that a furnace is polychreſt when it is ſo conſtructed that different operations may be made with it.

For the ſame reaſon, the inventors of ſome ſalts have given them this epithet to denote their various powers in medicine. Hence we have the *ſal polychreſt of Glaſer*, which is a vitriolated tartar, made by the detonation of nitre with ſulphur; the *ſal polychreſt of Rochelle* or *of Seignette*, which is a tartareous ſalt, or a ſoluble tartar with baſis of marine alkali. *See* Salt *of* Saignette, *and* Tartar (Vitriolated).

POTASH.

Potaſh is a [illegible] vegetable alkali, obtained from the aſhes of wood. *See* Alkali (Fixed Vegetable).

SALT *of* SAIGNETTE *or of* ROCHELLE.

This ſalt is a ſoluble tartar with baſis of marine alkali, or a neutral ſalt formed by ſaturating the acid of tartar with marine alkali.

This ſalt was firſt compoſed for medicinal purpoſes, in imitation of ordinary ſoluble tartar or vegetable ſalt, by Mr. Saignette, apothecary at Rochelle, who brought it into vogue, and kept it ſecret as long as he could. Meſſ. Boulduc and Geoffroy afterwards diſcovered, and publiſhed its compoſition.

To prepare this ſalt, cryſtals of marine alkali are to be diſſolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervеſcence ceaſes, more cream of tartar is to be added, till the liquor is ſaturated: it is then to be filtered and evaporated; and very fine and large cryſtals may be obtained by cold, each of which is the half of a polygonous priſm cut in the direction of its axis. This ſection, which forms a face much larger than the reſt, is, like them, a regular rectangle, diſtinguiſhable however from the others, not only by its breadth, but alſo by two diſtinct diagonal lines which interſect each other in the middle.

Mr. Beaumé has obſerved, that the cryſtallization of this ſalt, and alſo of the vegetable ſalt, is much more eaſy and beautiful when the liquor in which it is made contains an exceſs of alkali, which does not prevent the ſalt from being exactly neutral, after it has been well drained.

Salt of Saignette has a ſaline taſte, moderately ſtrong, and diſagreeable. It retains much water in its cryſtallization, is ſoluble in a leſs quantity of hot water than of cold water, and conſequently cryſtallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its cryſtallization, and from the marine alkali which enters its compoſition. In other reſpects, it has all the general properties of *neutral tartareous ſalts*, or *ſoluble tartars*.

Salt of Saignette is uſed only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much uſed as ſuch, and is, for that purpoſe, diſſolved in pure water, or in ptiſans and mineral waters, to render them purgative. It is alſo given in ſmall doſes of one or two gros, as an alterative, aperitive, and corrector of other purgative ſubſtances. Altho' this ſalt really poſſeſſes theſe good qualities, it does not ſeem to differ much from ordinary ſoluble tartar, to which it is generally preferred. *See* TARTAR, ALKALI (MINERAL), *and* TARTAR (SOLUBLE).

SALES SALSI.

This is one of the names given to neutral ſalts, particularly to thoſe which have a taſte ſomething reſembling that of common ſalt. *See* SALTS (NEUTRAL).

SEDATIVE SALT.

This ſalt is a ſaline, concrete, and cryſtallized ſubſtance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly ſaturates its alkali, has not an acid taſte, nor the property of reddening the tinctures of violets and turnſol, as the acids properly ſo called do. Sedative ſalt has little taſte and ſolubility in water. It is a kind of neutral ſalt, which has only ſome properties common to it with acids, as we ſhall afterwards ſee.

Sedative ſalt may be obtained from borax by ſublimation, or by cryſtallization. The moſt common proceſs for obtaining this ſalt by ſublimation is that of Homberg, the diſcoverer of ſedative ſalt This proceſs conſiſts in mixing martial vitriol with borax, in diſſolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a ſmall glaſs alembic, and the ſublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor paſſes into the receiver; but the internal ſurface of the capital is covered with a ſaline matter forming very ſmall, thin, laminated cryſtals, very ſhining and very light. This is the ſedative ſalt. The capital is then to be unluted, and the adhering ſalt ſwept off with a feather: the part of the liquor which paſſed laſt into the receiver is to be poured on the dry reſiduum of the cucurbit, and a new ſublimation is to be promoted as before, by diſtilling till the matter in the cucurbit be dry: theſe operations are to be frequently repeated in the ſame manner, till no more ſedative ſalt can be ſublimed.

Sedative ſalt may be obtained by cryſtallization. For this purpoſe, let borax be diſſolved in hot water; and to this ſolution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be ſaturated, and even have an exceſs of acid, according to Mr. Beaumé's proceſs: the liquor is then to be left in a cold place, and a great number of ſmall, ſhining, laminated cryſtals will be formed: Theſe muſt be waſhed with a little very cold water, and drained upon brown paper. This is the ſedative ſalt obtained by cryſtallization. It is very beautiful and ſhining, but is ſomewhat denſer than the ſalt obtained by ſublimation. This latter is ſo light, that one gros is ſufficient to fill a large phial.

The acids, either of the martial vitriol, or the diſengaged acids in the latter proceſs, do only diſengage this ſalt from the marine alkali with which it formed borax, as Mr. Baron has diſcovered. Accordingly, this ſalt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been diſengaged. Sedative ſalt obtained by cryſtallization does not differ eſſentially from that which is ſublimed, only that the cryſtals or laminæ of the latter are more ſeparated and detached than thoſe of the former.

Sedative ſalt, although it be thus ſublimed, is not however volatile; for, as Mr. Rouelle obſerves, it only riſes by means of the water of its cryſtallization. We know that, when once it has loſt its water by drying, it cannot be raiſed into vapors by the moſt violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified ſedative ſalt preſerves its ſaline character; and, although it has a beautiful cryſtalline appearance, it is only ſedative ſalt deprived of all moiſture and melted. It is entirely ſoluble in water, and may then be cryſtallized or ſublimed, as at firſt, into its proper form.

A great quantity of water is required to diſſolve ſedative ſalt, and much more of cold than of boiling water. It may therefore be cryſtallized by cold, and is alſo cryſtallizable by evaporation alone.

Mr. Beaumé has made an intereſting obſervation upon this method of diſengaging and cryſtallizing ſedative ſalt, which is, that we muſt add a little more acid to the ſolution than is ſufficient for the ſaturation. He remarks, that when only the preciſe quantity of acid is added to decompoſe all the borax, the ſedative ſalt remains confounded with the other ſaline matters contained in the liquor and the cryſtallization is conſequently diſturbed. This inconvenience is avoided by the addition of a little more acid than is ſufficient for the ſaturation of the alkaline baſis of the borax. The ſedative ſalt, although formed in a liquor thus acidulated, may be entirely deprived of any exceſs of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaumé.

The acid that is mixed in the hot ſolution of borax decompoſes this ſalt, becomes ſaturated with its alkaline baſis, and inſtantly diſengages the ſedative ſalt; all which is effected without any efferveſcence. The ſedative ſalt does not cryſtallize as ſoon as it is diſengaged, although the liquor be at the point of cryſtallization, when only the preciſe quantity of water is added which is neceſſary for the ſolution of the borax. The heat is the cauſe of this; for as ſoon as the liquor cools, a conſiderable quantity of cryſtals is perceived.

From the above-mentioned properties of the ſedative ſalt, by which it reſiſts fire, ſo as to be capable of vitrification, without being otherwiſe altered, we may perceive that it is a ſaline compound, the principles of which are ſtrictly united, and very difficultly ſeparable. This truth has been illuſtrated by numerous and accurate experiments on this ſubject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From theſe experiments we find, that ſedative ſalt reſiſts the moſt powerful agents for the decompoſition of ſaline ſubſtances. It was unaltered by treatment with inflammable matters, with ſulphur, with mineral acids diſengaged, or united with metallic ſubſtances, and with ſpirit of wine. Mr. Bourdelin could only perceive ſome marks of an inflammable matter, and a little marine acid, in this ſalt. The former he diſcovered by a ſmell of ſulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a ſolution of mercury, by the liquor obtained from the diſtillation of a mixture of this ſalt with powder of charcoal. Mr. Bourdelin does not poſitively affirm the laſt propoſition; but acknowledges, with all chemiſts, that we do not know the nature of ſedative ſalt, from not having been able to decompoſe it.

As this ſalt has the property of diſengaging the acids of nitre and of common ſalt by uniting with their baſes, and alſo as it is very vitrifiable, and promotes the vitrification of other ſubſtances, moſt chemiſts believe that it is compoſed of vitriolic acid intimately combined with a fuſible and vitreſcible earth.

This is one of the ſalts which are ſoluble in ſpirit of wine, to the flame of which it communicates a green color. As only the ſaline combinations of copper are known to be capable of giving this color to the flame of ſpirit of wine, ſome chemiſts have been induced to believe, that ſedative ſalt might contain copper, or the calx of copper.

Laſtly, we may ſuſpect ſome analogy betwixt the ſedative ſalt, on one ſide, and arſenic and phoſphoric acid on the other, from ſome properties which each of theſe ſubſtances have, and particularly from their action upon certain ſalts, and from their vitreſcible quality. But theſe latter ſubſtances are not better known than ſedative ſalt; therefore all that we can ſay upon this ſubject is, that much yet remains to be diſcovered concerning all theſe matters.

Excepting the uſes of borax in vitrifications, and in fuſions and ſoldering of metals, ſedative ſalt is only employed in medicine. Homberg, its inventor, believed that he diſcovered in it a ſedative, antiſpaſmodic, and even narcotic quality, and thence called it the *narcotic ſalt of vitriol.*

It was generally employed in convulſive diſeaſes after the praiſes Homberg had beſtowed upon it; but its ſedative powers have not been well aſcertained. The beſt practitioners even affirm, that, to produce any effect, it muſt be given from half a gros to a gros, inſtead of doſes of a few grains, which were given at firſt. *See* BORAX. *(t)*

SALT *of* SODA.

This is one of the names given to marine or mineral alkali obtained from the aſhes of ſoda and of other maritime plants. *See* ALKALI (MINERAL).

SULPHUREOUS SALT *of* STAHL.

This name is given to a neutral ſalt, compoſed of volatile ſulphureous acid, combined to the point of ſaturation with fixed vegetable alkali.

(t) SEDATIVE SALT. Mr. Cadet has publiſhed, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of ſome experiments made by him upon borax and the ſedative ſalt. From theſe he infers, 1. that the acid contained in borax is the marine, he having made a corroſive ſublimate with this acid and the mercurius precipitatus per ſe. 2. That the ſedative ſalt does not exiſt in borax, but is produced during the proceſs. 3. That this ſedative ſalt is compoſed of the marine acid originally exiſting in the borax, of the vitriolic acid employed in the operation, and of a vitreſcible earth. 4. That this vitreſcible earth is the ſame as that which is generally ſeparated from borax during its ſolution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth conſiſts of a calx of copper, from which by reduction he obtained a regulus of copper. 6. That borax therefore is compoſed of a calx of copper united with marine acid, and with mineral alkali. The ſame chemiſt purpoſes to make further experiments on this ſingular ſalt.

This ſalt may be made either by ſaturating fixed alkali with volatile ſulphureous acid made in a cracked retort, in Stahl's manner, or by expoſing linen ſoaked in liquid fixed alkali to the vapors of ſulphur ſlowly burning. When this latter method is employed, the linen dries, becomes ſtiff, and ſhines with many ſmall, needle-like cryſtals, which are the ſulphureous ſalt.

Volatile ſulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiſton, which is only weakly united with it, but is however ſufficient to diſguiſe conſiderably the eſſential properties of this acid. Sulphureous vitriolic acid has not only a pungent ſmell and volatility which the pure vitriolic has not, but it alſo forms with different ſubſtances, particularly with fixed alkali, neutral ſalts very different from thoſe formed by the union of theſe ſubſtances with pure vitriolic acid. Stahl firſt obſerved this ſalt, which is the only one known of all the combinations of the ſulphureous acid.

This ſulphureous ſalt has a more pungent taſte than vitriolated tartar, is more ſoluble in water, and is cryſtallizable by cold. Its cryſtals are like needles attached to each other by their ends, forming tufted cluſters of cryſtals; in which reſpect alſo it differs from vitriolated tartar, and is ſomewhat analogous to nitre.

This ſalt may be decompoſed by any acid, and its ſulphureous acid expelled from it. Thus vitriolic acid, from being naturally the ſtrongeſt of any, is rendered the weakeſt of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogiſtic principle, and its weak adheſion to the volatile ſulphureous acid, occaſion a gradual change of the nature of the ſulphureous ſalt. This ſalt is perpetually changing, from the conſtant diſſipation of its phlogiſton. It gradually loſes its peculiar properties by which it differs from vitriolated tartar, becomes more and more ſimilar to this ſalt, and at laſt, when it has loſt all its phlogiſton, does not in any reſpect differ from it. Probably we might obſerve the ſame changes in the combinations of ſulphureous acid with other ſubſtances; nevertheleſs thoſe which, like metals, have a ſtronger affinity with phlogiſton than alkali has, may perhaps produce effects very different.

All the phenomena of the ſulphureous ſalt, of the volatile ſulphureous acid, and of ſulphur, with regard to their ſeveral combinations, are naturally deducible from this general principle, that the affinities of the moſt compound bodies are always weaker than thoſe of the moſt ſimple ſubſtances. *See* VOLATILE SULPHUREOUS ACID, *and* ACID (VITRIOLIC).

FEBRIFUGAL SALT *of* SYLVIUS.

This is a neutral ſalt compoſed of marine acid ſaturated with fixed vegetable alkali. It is alſo called *regenerated ſea ſalt*, but improperly, becauſe the baſis is different from that of ſea ſalt. Excepting its taſte, which is not ſo agreeable as that of ſea ſalt, it reſembles this ſalt in its cryſtallization, and in moſt of its eſſential properties. It does not ſeem to deſerve the epithet *febrifugal*, although it may, when given in proper doſes as a purgative and antiſeptic, contribute to the cure of ſome fevers, which qualities are common to it with other neutral ſalts. It is not now employed. *See* Acid (Marine), Alkali (Fixed), *and* Neutral Salts.

SALTS *of* TAKENIUS.

The ſalts prepared in Takenius's manner are impure fixed alkalis, obtained from the aſhes of vegetables burnt for that purpoſe in a peculiar manner, namely, by ſuffocating their flame, and leaving no more communication with the air than is ſufficient for the burning of their moſt diſengaged inflammable parts.

When therefore we would prepare the fixed ſalts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated ſo that its bottom ſhall be red. The plant muſt be continually ſtirred; a thick fume will exhale from it, and at length a flame riſes. The pot is then to be covered with a lid, which muſt be ſo looſe that the flame only will be extinguiſhed, and the ſmoke will paſs out. The lid muſt be taken off ſometimes, that the plant may be ſtirred. When the plant is by this method reduced to a kind of aſhes, theſe aſhes muſt be lixiviated with boiling water; and when the lixivium has been evaporated to dryneſs, a ſaline matter more or leſs reddiſh will remain, which ought to be kept in a bottle. This is the fixed ſalt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogiſticated, rendered ſemi-ſaponaceous, ſimilar to that which is prepared for the making of Pruſſian blue, and mixed with all the neutral ſalts contained in the plant. Theſe impure alkalis have been intended only for medicinal uſes. Some perſons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed ſalts of different plants, prepared in this method, differ conſiderably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as theſe principles are totally changed, and decompoſed by burning, even when they are made with the precautions which Takenius mentions, theſe ſalts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only ſemi-ſaponaceous fixed alkalis, much leſs cauſtic than well purified alkalis, and which therefore may be preferred in medicine. Theſe alkalis partake beſides of the virtues of the neutral ſalts with which they are mixed.

SALT *of* TARTAR.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. *See* Alkali (Fixed).

VEGETABLE SALT.

This ſalt, called alſo *ſoluble tartar*, and *tartariſed tartar*, is a combination to the point of ſaturation of cream of tartar, or acid of tartar with fixed vegetable alkali. It is prepared and cryſtalliſed like ſalt of Saignette, from which it differs in its alkaline baſis. The cryſtals of this ſalt are much ſmaller than thoſe of ſalt of Saignette. In other reſpects it has the ſame properties, chemical and medicinal. *See* SALT *of* SAIGNETTE, TARTAR, *and* TARTAR (SOLUBLE).

SALT *of* VINEGAR.

The ſalt ſold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very ſtrong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete ſtate but with very great difficulty, and as it does not retain this concrete ſtate when it has once received it, as the Count de Lauraguais has ſhewn, when a ſalt of vinegar is required with a very pungent and penetrating ſmell, to be kept in bottles, like the concrete volatile alkali called ſalt of England, a better expedient has not been found than that we have mentioned. This mixture has a ſmell of radical vinegar, almoſt as pungent as that of volatile alkali, although the kind be very different; and is applicable to the ſame purpoſes, namely, to relieve hyſterical paroxyſms. *See* VINEGAR.

VOLATILE SALTS.

This name is frequently given to volatile concrete alkaline ſalts. Thus *volatile ſal ammoniac*, and *volatile ſalt of hartſhorn*, are the volatile alkalis obtained from theſe ſubſtances. Nevertheleſs, the ſame name is ſometimes given to other ſaline ſubſtances of very different natures, for inſtance, *the ſalt of amber*, which is acid, and is called *volatile ſalt of amber*, which is certainly an inconvenience. The appellation *volatile ſalt* may be given to all ſaline matters really volatile, that is, which may be ſublimed with a moderate heat. But as theſe ſalts are of very different kinds, they ought to be diſtinguiſhed by ſome more particular name. The volatility of ſalts is a very indeterminate quality. For of thoſe which are conſidered as ſuch, ſome are much more, and ſome much leſs volatile than others.

Theſe ſalts are called *ſemi-volatile* which cannot be ſublimed without a fire ſufficient to render the bottom of the veſſel containing them red-hot, ſuch as moſt ammoniacal ſalts, ſweet mercury, and ſome others. And thoſe are called *fixed ſalts* which may be kept red-hot during a certain time without ſenſible loſs. But, rigorouſly ſpeaking, no ſalts are abſolutely fixed; for, as we have ſaid elſewhere, the alkalis called fixed, and the other ſalts which are conſidered alſo as fixed, are diſſipated in fume when long expoſed to violent fire, with acceſs of air. *See* ALKALIS (VOLATILE), FIXITY, VOLATILITY.

URINOUS SALTS.

This name was given by ancient chemiſts to all alkaline ſalts, volatile or fixed; to the former, becauſe they all have the taſte of putrefied or diſtilled urine; and to the fixed, becauſe although they have not themſelves this taſte, they however occaſion it, when applied to the tongue, by diſengaging the volatile alkali contained in animal ſubſtances. Therefore *urinous ſalts* and *alkaline ſalts* are ſynonimous. *See* ALKALI.

SALT *of* STEEL.

Some chemiſts have given this name to ſeveral combinations of iron with acids, even to martial vitriol, as appears from *Riverius's ſalt of ſteel*, which is a martial vitriol made with iron, vitriolic acid, and ſpirit of wine. *See* VITRIOL.

DCIX. SALT-PETRE. *See* NITRE.

DCX. SAND. Sand is compoſed of ſmall ſtoney matters. The kinds of ſand may therefore be as many as the kinds of ſtones. Moſt ſands conſiſt of different kinds of ſtones mixed together. But as ſoft ſtones are eaſily reducible into ſo ſmall particles, that they are more like powders or earths than ſand; and as the molecules of hard or vitrifiable ſtones are capable of preſerving longer their ſize; hence moſt matters called ſand are of the nature of vitrifiable earths. *See* EARTHS (VITRIFIABLE). Accordingly, by the name of ſand, we underſtand always, in natural hiſtory and in chemiſtry, a matter of the nature of vitrifiable earths.

The principal uſe of ſand in chemiſtry is in compoſitions for pottery and glaſs. Some ſands are more and ſome leſs fuſible. The particles alſo of ſome are larger than thoſe of others. The finer kind is generally uſed for vitrifications, and other chemical operations, becauſe it is naturally much divided: It is frequently employed to make a *ſand-bath* to tranſmit heat to veſſels placed in it.

DCXI. SANDARACH. This is a yellow or red combination of arſenic with ſulphur. *See* ARSENIC, *and* REALGAR.

DCXII. SANDIVER. *See* GLASS-GALL.

DCXIII. SAPHIRE. (u)

DCXIV. SARCOCOLLA. (x)

DCXV. SARSAPARILLA. (y)

DCXVI. SASSAFRAS. (z)

(u) SAPHIRE is the name of a pellucid blue gem, the hardneſs of which is next to that of the ruby. By fire it is unfuſible, but its color is thereby deſtructible. It may be imitated by fuſing a hundred parts of cryſtal-glaſs-fritt with one part of zaffre, and a very ſmall proportion of mangan eſe.

(x) SARCOCOLLA is a gum-reſin, of an ounce of which ſix drams were found to be ſoluble by ſpirit of wine; and ſeven drams and a half were found to be ſoluble by water. *Neuman.*

(y) SARSAPARILLA. From ſixteen drams of this root Neuman obtained by water ſix drams of gummy extract, and from an equal quantity he obtained by ſpirit four drams of reſinous extract.

(z) SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neuman obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood, two drams were extracted by water. *Neuman.*

DCXVII. SATURATION. All the particles of matter have, as is ſaid under the articles AFFINITY, COMBINATION, SOLUTION, *and* GRAVITY, a tendency to unite one with another. In fact, when they are united, and when this tendency is ſatisfied, it is called the ſtate of *ſaturation*, and then the whole effect of this tendency, or of this force, conſiſts in making them cohere together. But all the phenomena of chemiſtry ſhow, that the tendency to union of the parts of different ſubſtances is more or leſs ſtrong, according to the nature of theſe ſubſtances. Hence the parts of two ſubſtances may be united together with all the force of which they are ſuſceptible, reſpectively to each other, although their tendency to union in general be very far from being entirely exhauſted and ſatisfied.

This remark leads us to conſider ſaturation in two views, that is, that we ſhould diſtinguiſh the ſaturation of one ſubſtance relatively to another, from the greater or leſs diminution of tendency to union in general, which a ſubſtance has ſuſtained by means of any particular union contracted. This latter we ſhall call *abſolute ſaturation*, and the former *relative ſaturation*.

Theſe things being premiſed, as the general tendency to union diminiſhes always in proportion to the force with which the parts are united, hence the adheſion, more or leſs ſtrong, contracted betwixt the principles of any compound, influences much the nature and eſſential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative ſaturation is then confounded with their abſolute ſaturation, ſo that after their union, no tendency to new unions can be perceived in theſe bodies, or in any of their principles. Such are the neutral ſalts compoſed of mineral acids and fixed alkali. So ſtrong an union is contracted by the acid and alkaline principles of theſe ſalts, that they loſe entirely, or almoſt entirely, their taſte, cauſticity, activity; in a word, all the properties which before this union were occaſioned by their general tendency to combination. Accordingly, the relative ſaturation of theſe is very diſtinct, and is one of the firſt which has been obſerved.

When, on the contrary, the principles of a compound can contract together only a weak union, and conſequently do not exhauſt by this union all their general tendency to combination, not only their point of relative ſaturation is leſs diſtinct, but alſo theſe principles, although relatively ſaturated by each other, are far from abſolute ſaturation, and ſtill preſerve, notwithſtanding this union, much of their diſſolving power. Compounds of this kind are always conſiderably active, and even cauſtic according to the nature of their principles. Such are deliqueſcent ſalts, and particularly moſt ſalts compoſed of mineral acids and metallic ſubſtances, the cauſticity of which cannot be otherwiſe explained. *See the articles* CAUSTICITY, *and* SUBLIMATE (CORROSIVE).

Many ſubſtances have a determinate and conſiderably diſtinct point of relative ſaturation, altho' they contract together but a weak union. But if we attend, we ſhall perceive that all theſe ſubſtances poſſeſs but a ſmall quantity of diſſolving power, or a weak general tendency to combination. Their relative ſaturation is nearly equal to their abſolute ſaturation. Such are ether with water, eſſential oils with ſpirit of wine, and moſt neutral ſalts with water. If we mix together and agitate good ether with water, a part of the ether unites with the water, nearly in the proportion of one to ten; ſo that if one part of ether be added to ten parts of water, all the ether diſappears by being diffuſed through the water, as the Count de Lauraguais obſerves. If the quantity of ether be more than one tenth part of the water, the overplus will float diſtinct upon the ſurface of the water, like an oil.

Alſo well rectified ſpirit of wine can only diſſolve a determinate quantity of each kind of eſſential oil, which quantity varies according to the kind of oil, and to the ſtate in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a reſinous ſtate, and the ſmaller quantity of them is ſoluble. And alſo the more highly rectified a ſpirit of wine is, the larger quantity of oil it diſſolves.

Water is the proper ſolvent of neutral ſalts. It is capable of diſſolving any of them, but moſt of them only in a certain quantity: and this point of ſaturation of water differs with different ſalts, and degrees of heat applied. The point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: But boiling water diſſolves an equal, or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Many ſubſtances are capable of uniting without being preciſely ſaturated, ſuch as water with any of the following ſubſtances; fluor acids, fixed vegetable alkali, fluor volatile alkali, moſt of the very deliqueſcent neutral ſalts, and ſpirit of wine. Such alſo are almoſt all metals uniting with each other: Although many of theſe ſubſtances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, their union is little elſe than a very accurate and intimate mixture. Their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no preciſe or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of relative ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more compleatly exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object as important as it is new in chemiſtry. This matter has been ſcarcely begun, and yet it well deſerves the attention of chemiſts, as it would greatly advance the ſcience. We could not treat this ſubject more fully without repeating what has been ſaid elſewhere. We therefore refer to the articles *affinity*, *combination*, *compoſition*, *ſolution*, *cauſticity*, *gravity*, *ſalts*, *neutral ſalts*, *corroſive ſublimate*; and ſeveral others.

DCXVIII. SAUNDERS. (*a*)

DCXIX. SCAMMONY. (*b*)

DCXX. SCORDIUM. (*c*)

DCXXI. SEA-WATER. *See* Water.

DCXXII. SELENITES. Modern chemiſts give this name to a ſort of neutral ſalt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of ſaturation in the moſt intimate manner. Probably a very conſiderable quantity of earth enters into this combination, at leaſt if we judge of it by the ſaturation of vitriolic acid, which appears to be more compleat than in any of the other neutral ſalts formed with this acid. This truth is ſufficiently eſtabliſhed by the properties of ſelenites.

Nature furniſhes us with a very large quantity of ſelenitic matters. Chemiſts agree that all gypſums or plaſter-ſtones, alabaſters, and gypſeous ſpars, are nothing elſe than ſelenites; but theſe ſubſtances are in large quantities within and upon the earth. We may alſo artificially compoſe ſelenites, by combining vitriolic acid to the point of ſaturation with calcareous earth. To effect this ſaturation eaſily, the calcareous earth muſt be in fine powder, the acid muſt be diluted in a very large quantity of water, and more earth muſt be added than is neceſſary for the ſaturation. Selenites may alſo be conveniently made by

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(*a*) Saunders. The wood of the tree, called *red ſaunders*, contains a red coloring material uſed in dying. Its color reſides wholly in a reſinous matter, and hence is extractable by ſpirit of wine, and not by water. The red color of Saunders, imparted to ſpirit of wine, becomes, by diluting the tincture with more ſpirit, yellow. The reſin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniſeeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow ſaunders*, is from its fragrance ſometimes employed as a perfume. From ſixteen ounces of the raſped wood, digeſted ſome days in ſalt water, two drams eſſential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood, by water; and from an equal quantity of wood, two drams and a half of reſinous extract may be obtained by rectified ſpirit. *Neuman.*

(*b*) Scammony is a gummy-reſinous juice, which exſudes from the root of a ſpecies of convolvulus, in which inciſions are purpoſely made at a certain ſeaſon of the year. An ounce of Smyrna ſcammony yielded with water half an ounce of gummy extract, and the reſiduum yielded with ſpirit two drams of reſin, leaving two drams of impurities undiſſolved. By applying rectified ſpirit at firſt to an ounce of the ſame ſcammony, two drams and two ſcruples of reſinous extract were obtained; and from the reſiduum, water extracted half an ounce of gum, the indiſſoluble part amounting here to four ſcruples only. *Neuman.*

(*c*) Scordium. An ounce of the dried leaves of ſcordium yielded with water four drams and a half of gummy extract, and afterwards with rectified ſpirit fifteen grains of reſin. Another ounce, treated firſt with ſpirit, gave three drams of reſinous extract, and afterwards with water, five ſcruples and a half of gum. A tincture, made in highly rectified ſpirit of wine, contains more of the active and leſs of the mucilaginous parts of this plant, than one made with a weaker ſpirit.

ſaturating lime-water gradually with weak vitriolic acid, or, laſtly, by pouring this acid into a ſolution of nitrous or marine ſalts with calcareous baſes. In theſe latter operations the ſelenitic ſalt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well waſhed from all exceſs of acid or other extraneous matter, has a ſlightly nauſeous taſte, which is ſcarcely perceptible but by drinking a glaſs of water impregnated with it, like that of the wells in and near Paris, the ſweetiſh and ſlightly nauſeous taſte of which is well known.

This earthy ſalt is one of the leaſt ſoluble by water of all the known neutral ſalts. Seven or eight hundred parts of water are required to diſſolve one part of ſelenites, excepting when its principles are combined, and the ſalt formed in the water, as Mr. Beaume has obſerved; for then the water may diſſolve four or five times as much. By a ſlow evaporation it cryſtallizes, and forms thin laminæ, and retains in its cryſtallization a very ſmall quantity of water.

When it is expoſed to a moderate fire, it eaſily loſes this water of its cryſtallization with its tranſparency and coheſion of its parts, and is reduced to a white powder.

With a very great fire, it is not fuſible when alone, *(d)* but is more eaſily fuſible than pure calcareous earth, by the addition of fluxes, as ſand, and clay, and vitrifying ſalts. It reſiſts the greateſt heat without loſing its acid. It cannot be decompoſed but by phlogiſton, by alkalis fixed or volatile; and by metallic ſolutions in nitrous acid, by means of a double affinity. Thus the ſolution of mercury readily ſhews whether a water be ſelenitic or not, by forming a precipitate of turbith mineral when added to ſuch waters. As ſelenitic matters are copiouſly diffuſed, and almoſt every where within the earth, moſt waters of wells, or rivers, contain a greater or leſs quantity of ſelenites diſſolved in them, as we may eaſily find by the abovementioned method of trial.

Nothing better ſhews the extreme difference betwixt vitriolic and other mineral acids, than the compariſon of the ſaline properties of ſelenites with thoſe of nitrous and marine ſalts with calcareous baſes. The earthy baſis is the ſame in theſe three ſalts; but the two latter have a violent, almoſt cauſtic taſte, and are ſurpriſingly deliqueſcent; while the firſt ſalt is very difficultly ſoluble in water, and almoſt inſipid. The cauſe of theſe differences is, that vitriolic acid is more ſimple than the other acids, and is therefore capable of being more intimately combined and ſaturated with calcareous earth.

This kind of ſalt has been called ſelenites probably becauſe naturaliſts found its ſaline properties ſo weak, that they thought it ought to be diſtinguiſhed from other neutral ſalts by a peculiar name. Perhaps they did not even believe it to be ſaline; for the nature of ſelenitic matters has been diſcovered but lately by experiments of modern chemiſts.

We are not yet enough acquainted with calcareous earths to know if ſelenites be of different kinds, or if all the ſubſtances to which this name is given are only one and the ſame ſalt under different forms of cryſtallization. If the kinds of calcareous earth be eſſentially different, they muſt form with vitriolic

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(d) From Mr. D'Arcet's Memoir upon the effects of a violent and long continued heat, we find that all gypſeous ſtones, and alſo the artificial ſelenitic ſalts, are fuſible and vitreſcible by violent fire.

acid ſeveral kinds of ſelenites alſo eſſentially different from each other. But if only one kind of calcareous earth exiſts, then it can only form one kind of ſelenites.

We may obſerve, that amongſt the various bodies called by chemiſts ſelenites, that is, compounds of vitriolic acid with calcareous earths, ſome differ much from others, at leaſt externally. Theſe ſubſtances are all the gypſums, alabaſters, and ſpars, which ſome chemiſts, particularly Mr. Pott, have called gypſeous, and, laſtly, ſome cryſtallizations and ſtalactites, which have the ſame principles and the ſame eſſential properties as other ſelenitic ſubſtances. *See* Acid (Vitriolic), Alabaster, Gypsum, Spar, *and* Earth (Calcareous).

DCXXIII. SEMI-METAL. Subſtances poſſeſſing all the metallic properties, excepting fixity and ductility, are called *ſemi-metals*. Thus every matter poſſeſſed of metallic denſity, opacity, and luſtre, which is incapable of uniting with earths, but which is alſo brittle and frangible by the ſtroke of a hammer, and capable of being ſublimed or reduced into vapors by fire, is a ſemi-metal. Hitherto we know but five ſemi-metals, which are *regulus of antimony*, *zinc*, *biſmuth*, *regulus of cobalt*, *and regulus of arſenic*.

Some chemiſts have numbered mercury amongſt the ſemi-metals, under pretence that it poſſeſſed all the metallic properties excepting fixity and ductility: but all ſemi-metals are combuſtible, and mercury is no more ſo than the perfect metals; and alſo, the want of ductility is falſely imputed to it, ſince the Academicians of Peterſbourg, who ſome years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary ſtate, the cauſe of this appears to be, that it is really in fuſion: but the moſt ductile metals loſe their ductility by fuſion, as this quality neceſſarily implies ſolidity. On the other ſide, the great volatility of mercury does not allow us to claſs it among metals. This metallic ſubſtance is therefore ſingle in its kind, and is really neither a metal nor a ſemi-metal. *See* Mercury.

Mr. Cronſtedt has given, in the Memoirs of the Swediſh Academy for the year 1751, a deſcription of a new ſemi-metal: but this metallic ſubſtance is hitherto but little known. *(e)*

DCXXIV. SENA. *(f)*

(e) Concerning this new ſemi-metal diſcovered by Mr. Cronſtedt, *ſee the article* Nickel. *See alſo the note (y) to the article* Metals, concerning another new ſemi-metal which Mr. Juſti ſays that he has diſcovered in the yellow mica.

(f) Sena. An ounce of the leaves of Sena, treated with freſh parcels of rectified ſpirit of wine, yielded two drams and twenty-three grains of reſinous extract; and afterwards with water, two drams and two ſcruples of gummy extract; three drams and three grains remaining undiſſolved. Another ounce, treated firſt with water, gave four drams and half a ſcruple of gummy, and afterwards with ſpirit only, twenty-eight grains of a reſinous extract, which appeared to contain ſome groſs oily matter; and hence was difficultly reduced to dryneſs. The reſiduum weighed three drams and a ſcruple. Water diſtilled from Sena poſſeſſes the peculiar ſmell of theſe leaves, but no eſſential oil appears. The activity of Sena is greatly weakened by evaporation, eſpecially if the proceſs be performed in an open veſſel with a boiling heat. *Neuman.*

DCXXV. SENEGAL (GUM) (g)

DCXXVI. SERPENTINE-STONE. (h)

DCXXVII. SILK. (i)

DCXXVIII. SILVER. Silver, called alſo *luna* by chemiſts, is a perfect metal, of a ſhining white color.

Its ſpecific gravity is, although conſiderable, nearly one half leſs than that of gold. It loſes in water an eleventh part of its weight. A cubic foot of ſilver weighs 720 pounds.

The tenacity of its parts is alſo nearly one half leſs than that of gold; a ſilver wire, the diameter of which is $\frac{1}{10}$ part of an inch, can ſupport only a weight of 270 pounds without breaking.

This metal is, next to gold, the moſt ductile of all. Very fine wire and leaf may be formed of it.

It is ſomewhat ſonorous and harder than gold, as Juncker obſerves; and is fuſible with a leſs degree of heat than gold is, according to Cramer. It ſeems to be as fixed and indeſtructible as gold is. Kunckel kept ſilver and gold in a glaſs-houſe-furnace during a month without alteration, or more loſs than of a few grains, which probably proceeded from a ſmall quantity of extraneous matter, with which it was mixed.

Juncker nevertheleſs affirms, that ſilver may be changed into a vitreſcent calx, when treated by a long reverberation in the manner of Iſaacus Hollandus. This reverberation, conſiſts in expoſing metals, reduced into very fine parts, to the action of the ſtrongeſt heat they can ſuſtain without fuſion, with the contact of free air. This method is very effectual for burning the inflammable principle of metals and of all other bodies. But Juncker does not mention the author of this experiment.

The combined action of air and water does not alter the color and brilliancy of ſilver, nor occaſion any ruſt. Nevertheleſs, the ſurface of this metal is apt to tarniſh, and even to become black, by the contact of the phlogiſton of ſeveral inflammable matters, or of their exhalations; becauſe it has the property of impregnating itſelf with the inflammable principle ſuperabundantly, even in the cold, like ſome other metallic matters: but ſilver ſeems to be more ſuſceptible of this effect than any other metal.

All acids are, with more or leſs facility, capable of diſſolving ſilver.

Vitriolic and marine acids may be combined with ſilver in its metallic ſtate; but difficultly, and by particular management.

To diſſolve ſilver directly, vitriolic acid muſt be much concentrated and very hot; and therefore diſtillation is neceſſary, as in the operation of turbith mineral. *See* TURBITH MINERAL.

(g) SENEGAL (GUM) is a gum, almoſt pure, and entirely ſimilar in properties to the other pure gums, as gum arabic, cherry-tree and plumb-tree gums. *See* GUM.

(h) SERPENTINE STONE is a ſteatites variouſly colored, but in which the green color generally predominates. *See* STEATITES.

(i) SILK is an animal ſubſtance, from 16 oz. of which may be obtained, by diſtillation, nine ounces of mixed matters, containing four ounces and two drams of urinous ſpirit, three ounces ſix drams of volatile ſalt, and one ounce of empyreumatic oil. The caput mortuum weighed ſeven ounces, and loſt an ounce on being calcined to whiteneſs. By elixating the calx, forty grains of fixed ſaline matter were alſo obtained. *Neuman.*

The marine acid cannot attack ſilver directly; but when it is very much dephlegmated, and, as it were, in a dry ſtate, conſiderably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. *See* PARTING (CONCENTRATED).

But ſilver may be combined with the above-mentioned acids, by methods much more ſimple and convenient, which we ſhall deſcribe, after having ſpoken of the ſolution of ſilver by nitrous acid.

Nitrous acid, very pure and moderately ſtrong, diſſolves ſilver in its metallic ſtate with the greateſt facility. This ſolution is made ſpontaneouſly without heat, or with a very gentle heat at firſt; and when the ſilver has begun to diſſolve, the heat ought to be diſcontinued, to prevent the ſolution from being too violent, eſpecially if the quantities operated upon be conſiderable.

By this method nitrous acid may be ſaturated with ſilver; and if it be ſtrong, it will diſſolve a conſiderable quantity of that metal.

If the ſilver thus diſſolved be allayed with copper, the ſolution will be green, and will preſerve this color. If it contain no copper, the ſolution is at firſt greeniſh, which color gradually diſſipates, and at laſt the liquor becomes quite white.

The ſurface of the ſilver begins to become black as ſoon as the acid makes impreſſion upon it. This blackneſs proceeds from a part of the phlogiſton of the nitrous acid, which is applied ſuperabundantly to the ſurface of the ſilver.

Black flocks are frequently ſeen floating in this ſolution, which are inſoluble by nitrous acid, and precipitate to the bottom. Theſe flocks may be a ſmall quantity of gold from which ſilver is ſeldom entirely free, or of ſome other phlogiſticated ſubſtance, inſoluble in nitrous acid.

The ſolution of ſilver by nitrous acid is more acrid and corroſive than pure nitrous acid; which property is very remarkable, and is common to it with ſeveral other combinations of metals. *See an explanation of this property under the article* CAUSTICITY.

This ſolution of ſilver corrodes all vegetable and animal matters, and ſtains the ſkin of a black color, which cannot be effaced till the blackened part be abraded. This blackneſs can be only attributed to the phlogiſton of corroded matters, which unites ſuperabundantly with the ſilver of the ſolution employed.

If a ſolution of ſilver by nitrous acid be ſufficiently evaporated, and left to cool, a large quantity of white cryſtals will be formed in it, like ſcales, which are commonly called *cryſtals of ſilver*. Theſe cryſtals are a nitrous ſalt, the baſis of which is ſilver; for which reaſon it may alſo be called ***nitre with baſis of ſilver***, or *lunar nitre*.

This ſalt is fuſible with a ſmall heat, and eaſily loſes the water of its cryſtallization. It becomes black, congeals by cold, and is capable of being moulded. It is then the famous cautery uſed by ſurgeons, and known by the name of *lapis infernalis*. *See the words* PARTING, CRYSTALS *of* SILVER, *and* LAPIS INFERNALIS.

Lunar nitre deflagrates upon coals almoſt as well as the nitre with baſis of fixed alkali, which ſhews a ſtrong adheſion of nitrous acid with ſilver. Nevertheleſs, this ſalt expoſed to ſtrong fire in diſtilling veſſels, or in a crucible, may be eaſily decompoſed. The acid quits the ſilver, and appears in its former ſtate.

Although ſilver, as we have ſeen, is more eaſily ſoluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of ſeparating it from the nitrous acid, after this has diſſolved it.

If vitriolic acid be poured into a ſolution of ſilver in nitrous acid, and if it be not diluted in too great a quantity of water, we ſee immediately the liquors become turbid, and a white precipitate appears, which is nothing elſe than a new combination made of the ſilver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new ſalt with metallic baſis. This ſalt which may properly be called *vitriol of ſilver*, or *lunar vitriol*, is cryſtallizable, and actually does cryſtallize in the very inſtant of precipitation; but the cryſtals are ſo ſmall, from the rapidity of the cryſtallization, that they have only the appearance of a white powder. They cannot be diſcovered to be cryſtals but by means of a good magnifying glaſs.

The ſame event happens, if, inſtead of vitriolic acid, a ſolution of any ſalt containing that acid be added to a ſolution of ſilver in nitrous acid. The nitre of ſilver will be thereby decompoſed, and a vitriol of ſilver obtained ſimilar to the former.

Although vitriolic acid engaged in any baſis, ſuch as fixed alkali, with which it has a ſtronger affinity than with ſilver, does nevertheleſs quit its baſis to combine with this metal, yet we may obſerve, that in theſe precipitations two decompoſitions and two new combinations are always effected, by means of a double affinity. We may therefore ſee the explanation of this caſe at the word AFFINITY.

Marine acid, whether engaged in any baſis, or diſengaged, produces in the ſolution of ſilver by nitrous acid the ſame effect as the vitriolic acid. It ſeparates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine ſalt with baſis of ſilver*, known to chemiſts by the name of *luna cornea*, or *corneous ſilver*. *See* LUNA CORNEA. It is called corneous, becauſe this ſilver, united with marine acid by expoſure to fire, may be melted; and may be coagulated by cold into a ſemi-tranſparent, ſemi-flexible maſs, like horn.

Luna cornea, although in a ſaline ſtate, is very little ſoluble by water. The precipitate which it forms is very apparent: it is compoſed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be diſtinguiſhed from vitriol of ſilver.

Theſe properties of a ſolution of ſilver, together with the facility with which it is rendered turbid by the preſence of the ſmalleſt quantity of vitriolic and marine acids, diſengaged or combined with any baſis, render it very convenient and much uſed for the examination of waters, and in other chemical operations, to aſcertain the preſence of theſe two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be ſeparated from any acid by abſorbent earths, or by fixed and volatile alkalis; and when afterwards fuſed, it recovers its original properties. Silver, thus diſſolved, precipitated, and melted, is generally very pure. We may be certain that ſilver, which has been formed into luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, copper, iron, or other metallic ſubſtance ſoluble in aqua regia, and conſequently not ſeparable from nitrous acid by means of marine acid.

From what has been ſaid concerning theſe ſeveral decompoſitions of a ſolution of ſilver made by nitrous acid, we may infer that this combination may be decompoſed;

1. By the action of fire alone, which expels the nitrous acid.

2. By phlogiſton, which burns and deſtroys nitrous acid in the detonation of lunar nitre.

3. By precipitation with ſaline or earthy alkalis, which ſeize the nitrous acid, and leave the ſilver diſengaged in the ſtate of a precipitate.

4. By vitriolic acid, which ſeizes the ſilver, and leaves the nitrous acid diſengaged.

5. By marine acid, which has the ſame effect.

6. Laſtly, ſeveral metals, and eſpecially copper, having a ſtronger affinity than ſilver with nitrous acid, decompoſe alſo this ſolution of ſilver, by ſeizing the acid, and obliging the ſilver to ſeparate from it, which it does by precipitating it in its proper metallic ſtate. *See the words* PRECIPITATE *and* PRECIPITATION.

Sulphur diſſolves ſilver by fuſion, and forms with it a blackiſh maſs, which may be cut, and which has almoſt the color and conſiſtence of lead. It is called *ſulphurated ſilver.* This compound is a kind of artificial ore of ſilver. Some expert perſons are ſaid to be able to imitate very well by this mixture ſome natural ores of ſilver.

To make this combination, ſilver and ſulphur are laid alternately upon each other in ſeveral ſtrata in a crucible, which is to be heated by degrees till the whole be fuſed. Leſs heat is required for this fuſion than if the ſilver was alone, becauſe ſulphur facilitates the fuſion of this, as well as of all other metals difficultly fuſible, upon which it is capable of acting.

The ſulphur may be ſeparated from the ſilver by the mere action of the fire, continued during a certain time with acceſs of air. When ſulphurated ſilver is detonated with nitre, this ſeparation is very well and inſtantly made. As this metal is indeſtructible by all theſe agents, it is found to be unchanged by theſe operations.

Juncker relates, after Kunckel, that if ſulphur be diſſipated from ſulphurated ſilver by the action of fire; and if a volatile alkaline ſpirit of urine be poured upon this ſilver, a blue color is produced. He adds alſo, that this does not happen a ſecond time to the ſame ſilver, unleſs it be firſt cupelled with lead. This chemiſt concludes from thence, that this color proceeds from copper which the ſilver receives from the lead. *See Conſpectus Chymiæ, Tom.* I. *p.* 893.

Silver is found within the earth in different ſtates. A very ſmall quantity of it is in its natural and malleable ſtate, allayed with copper and gold; and is then called *virgin* or *native ſilver*: but ſilver is generally found in a mineral ſtate, that is, united and incorporated with heterogeneous matters, ſuch as other metallic ſubſtances, and the mineraliſing ſubſtances, namely, ſulphur and arſenic. It is ſeparated from all theſe matters by particular proceſſes practiſed both in eſſays and in ſmelting the ore in large quantities. *See* ORES *of* SILVER.

Silver is purified from the allay of other deſtructible metals by treating it with nitre, or with lead. The latter method is generally uſed by refiners, and is called *cupellation*, or *refining*. *See* Refining.

All theſe operations are founded in general upon the deſtructibility of imperfect metals, and on the indeſtructibility of ſilver, which is a perfect metal: but as gold is an indeſtructible metal, all the purifications of ſilver, which are only effected by the deſtruction of metals allayed with it, are inſufficient to ſeparate it from gold. We muſt therefore have recourſe to other operations for the ſeparation of theſe two metals from each other. Theſe operations, which are called by the general name of *parting*, are founded upon the property which ſilver has of being ſoluble by many menſtrua which do not act upon gold. Theſe menſtrua are;

1. Nitrous acid, which diſſolves ſilver without touching gold. By means of this acid, ſilver is generally parted from gold, and the operation is called *parting*, without any epithet to diſtinguiſh it from the others. *See* Parting.

2. Marine acid, which being applied conveniently to a mixture of gold and ſilver, ſeizes this latter metal excluſively of the former. As this parting is performed by cementation, and as the marine acid muſt be highly concentrated, it is called concentrated parting. *See* Parting (Concentrated).

3. Laſtly, ſulphur, which unites alſo to ſilver without touching gold, furniſhes a third method of ſeparating theſe two metals. This is called *dry parting*, becauſe it is made by fuſion, which chemiſts call the *dry way*. *See* Parting (Dry).

Silver is capable of being allayed with all metals, and forms with them different compounds, the properties of which may be ſeen under the word Allay.

According to Mr. Geoffroy's table of affinities, thoſe of ſilver are firſt to lead, and then to copper, and Mr. Gellert's table mentions only gold.

DCXXIX. SIMILOR. This is a name given to an allay of red copper and zinc, made in the beſt proportions to imitate the color of gold. *See* Copper, Brass, *and* Zinc.

DCXXX. SMALT Is a blue glaſs compoſed of the calx of cobalt, vitrified and melted with ſome fritt of glaſs or cryſtal. Ground ſmalt is called *azure*, or *enamel blue*. *See* Azure, Cobalt, *and* Zaffre.

DCXXXI. SMELTING *of* ORES. We have ſhewn, under the articles *ores* and *pyrites*, the nature of the principal metallic minerals, and the ſubſtances of which they are compoſed. We have alſo explained, under the article *eſſay of ores*, the proceſſes by which an exact analyſis of theſe compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to compleat what relates to this important ſubject, we ſhall deſcribe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purpoſes, metals, ſulphur, vitriols, and other uſeful ſubſtances contained in metallic minerals: What we ſhall ſay upon this ſubject will chiefly be extracted from a *Treatiſe on the Smelting of Ores, by Schlutter*, tranſlated from the German into French by *M. Hellot*; becauſe this, of all the modern works upon that ſubject, appears to be the moſt exact. We ſhall firſt deſcribe the operations upon pyritous matters for the extraction of ſulphur, vitriols, and alum; and afterwards the operations by which metallic ſubſtances are extracted from ores properly ſo called; from which alſo are occaſionally obtained the ſame matters as from the pyrites. As the preſent article is only the ſequel of the articles *ores*, *pyrites*, and *eſſays of ores*, it is evident that theſe articles ought to be read previouſly to this.

EXTRACTION *of* SULPHUR *from* PYRITES *and other* MINERALS.

In order to obtain ſulphur from pyrites, this mineral ought to be expoſed to a heat ſufficient to ſublime the ſulphur, or to make it diſtill in veſſels, which muſt be cloſe, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Alten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made ſeveral openings. Theſe are called *furnaces for extracting ſulphur*. See PLATE II. *Fig* 9.

In theſe furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the ſize of ſmall nuts. Each of theſe tubes contains about fifty pounds of pyrites. They are placed in the furnace almoſt horizontally, and have ſcarcely more than an inch of deſcent. The ends, which come out of the furnace five or ſix inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a ſtar, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a ſmall hole to give air to the ſulphur. The other end of the tube is exactly cloſed A moderate fire is made with wood, and in eight hours the ſulphur of the pyrites is found to have paſſed into the receivers

The reſiduum of the pyrites, after the diſtillation, is drawn out at the large end, and freſh pyrites is put in its place From this reſiduum, which is called *burnings of ſulphur*, vitriol is extracted; as we ſhall preſently relate.

The eleven tubes into which were put, at three ſeveral diſtillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude ſulphur, which is ſo impure as to require to be purified by a ſecond diſtillation.

This purification of crude ſulphur is alſo done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each ſide. Theſe cucurbits are placed in a ſloping direction, and contain about eight quintals and a half of crude ſulphur. To them are luted earthen tubes, ſo diſpoſed as to anſwer the purpoſe of capitals. The noſe of each of theſe tubes is inſerted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the noſe of the tube; a ſecond ſmaller hole, which is left open to give air; and a third in its lower part, which is ſtopped with a wooden peg. *See* PLATE II. *Fig*. 10.

When the preparations are made, a fire is lighted about ſeven o'clock in the evening, and is a little abated as ſoon as the ſulphur begins to diſtill. At three o'clock in the morning, the wooden pegs, which ſtop the lower holes of the fore-runners, are for the firſt time drawn out, and the ſulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this diſtillation the fire muſt be moderated and prudently conducted; otherwiſe leſs ſulphur would be obtained, and it alſo would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loſs in the purification of eight quintals of crude ſulphur is, at moſt, one quintal.

When all the ſulphur has flowed out, and has cooled a little in the earthen pots, it is caſt into moulds made of beech tree, which have been previouſly dipt in water, and ſet to drain. As ſoon as the ſulphur is cooled in the moulds, they are opened, and the cylinders of ſulphur are taken out and put up in caſks. Theſe are called *roll-brimſtone*.

As ſulphur is not only in pyrites, but alſo in moſt metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it muſt be ſeparated previouſly to their fuſion: but as ſulphur is of little value, the trouble of collecting it from ores is ſeldom taken. Smelters are generally ſatisfied with freeing their ores from it, by expoſing them to a fire ſufficient to expell it. This operation is called *torrefaction*, or *roaſting of ores*.

There are, however, ores which contain ſo much ſulphur, that part of it is actually collected in the ordinary operation of roaſting, without much trouble for that purpoſe. Such is the ore of *Ramelſberg*, in the country of *Hartz*.

This ore, which is of lead, containing ſilver, is partly very pure, and partly mixed with cupreous pyrites and ſulphur; hence it is neceſſary to roaſt it.

The roaſting is performed by laying alternate ſtrata of ore and wood upon each other in an open field, taking care to diminiſh the ſize of the ſtrata as they riſe higher; ſo that the whole maſs ſhall be a quadrangular pyramid truncated above, whoſe baſe is about thirty-one feet ſquare. Below, ſome paſſages are left open, to give free entrance to the air; and the ſides and top of the pyramid are covered over with ſmall ore, to concentrate the heat and make it laſt longer. In the center of this pyramid there is a channel, which deſcends vertically from the top to the baſe. When all is properly arranged, ladle-fulls of red-hot ſcoria from the ſmelting furnace are thrown down the channel, by which means the ſhrubs and wood, placed below for that purpoſe, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the ſulphur of the mineral becomes capable of burning ſpontaneouſly, and of continuing the fire after the wood is conſumed.

When this roaſting has been continued fifteen days, the mineral becomes greaſy, that is, it is covered over with a kind of varniſh: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the ſulphur is collected. From theſe cavities the ſulphur is taken out thrice every day, and thrown into water. This ſulphur is not pure, but crude, and is therefore ſent to the manufacturers of ſulphur to be purified in the manner above related. *See* PLATE II. *Fig.* 11. *and* 12.

As this ore of Ramelſberg is very ſulphureous, the firſt roaſting, which we are now deſcribing, laſts three months; and during this time, if much rain has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has ſo much free acceſs, that the ſulphur is burnt and conſumed, from ten to twenty quintals of crude ſulphur are by this method collected.

The ſulphur of this ore, like that of moſt others, was formerly neglected, till, in the year 1570, a perſon employed in the mines, called Chriſtopher Sauder, diſcovered the method of collecting it, nearly as it is done at preſent.

Metallic minerals are not the only ſubſtances from which ſulphur is extracted. This matter is diffuſed in the earth in ſuch quantities, that the metals cannot abſorb it all. Some ſulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin ſulphur*, the tranſparent kind called *ſulphur of Quito*, and the native flowers of ſulphur, as thoſe of the waters of Aix-la-Chapelle. It is alſo found mixed with different earths. Here we may obſerve, that all thoſe kinds of ſulphur which are not mineraliſed by metallic ſubſtances, are found near volcanos, or hot mineral waters, and conſequently in places where nature ſeems to have formed great ſubterranean laboratories, in which ſulphureous minerals may be analyſed and decompoſed, and the ſulphur ſeparated, in the manner in which it is done in ſmall in our works and laboratories. However that be, certainly one of the beſt and moſt famous ſulphur-mines in the world is that called *Solfatara*. The Abbé Nollet has publiſhed, in the Memoirs of the Academy, ſome intereſting obſervations upon this ſubject, which we ſhall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of ſulphur and alum called at preſent *Solfatara*. It is a ſmall oval plain, the greateſt diameter of which is about 400 yards, raiſed about 300 yards above the level of the ſea. It is ſurrounded by high hills and great rocks, which fall to pieces, and whoſe fragments form very ſteep banks. Almoſt all the ground is bare and white, like marle, and is every where ſenſibly warmer than the atmoſphere in the greateſt heat of ſummer; ſo that the feet of perſons walking there are burnt through their ſhoes. It is impoſſible not to obſerve the ſulphur there; for every where may be perceived by the ſmell a ſulphureous vapor, which riſes to a conſiderable height, and gives reaſon to believe that there is a ſubterraneous fire below, from which that vapor proceeds.

Near the middle of this field there is a kind of baſon three or four feet lower than the reſt of the plain, in which a ſound may be perceived when a perſon walks on it, as if there were under his feet ſome great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whoſe waters ſeem to boil. Theſe waters are indeed hot, but not ſo hot as boiling water. This kind of ebullition proceeds from vapors which riſe from the bottom of the lake, which being ſet in motion by the action of ſubterraneous fires, have force enough to raiſe all that maſs of water. Near this lake there are pits, not very deep, from which ſulphureous vapors are exhaled. Perſons who have the itch, come to theſe pits, and receive the vapors in order to be cured. Finally, there are ſome deeper excavations, whence a ſoft ſtone is procured which yields ſulphur. From theſe cavities vapors exhale, and iſſue out with noiſe, and which are nothing elſe than ſulphur ſubliming through the crevices. This ſulphur adheres to the ſides of the rocks, where it forms enormous maſſes: in calm weather, the vapors may be evidently ſeen to riſe 25 or 30 feet from the ſurface of the earth.

Theſe vapors, attaching themſelves to the ſides of rocks, form enormous groups of ſulphur, which ſometimes fall down by their own weight, and render theſe places of dangerous acceſs.

In entering the Solfatara, there are warehouſes and buildings erected for the refining of ſulphur.

Under a great ſhed, or hangar, ſupported by a wall behind, and open on the other three ſides, the ſulphur is procured by diſtillation from the ſoft ſtones we mentioned above. Theſe ſtones are dug from under ground; and thoſe which lie on the ſurface of the earth are neglected. Theſe laſt are, however, covered with a ſulphur ready formed, and of a yellow color: but the workmen ſay they have loſt their *ſtrength*, and that the ſulphur obtained from them is not of ſo good a quality as the ſulphur obtained from the ſtones which are dug out of the ground.

Theſe laſt mentioned ſtones are broken into lumps, and put into pots of earthen ware, containing each about twenty pints, Paris meaſure. The mouths of theſe pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the ſame earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two ſides of a furnace. The pots are placed within theſe walls; ſo that the center of each pot is in the center of the thickneſs of the wall, and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of theſe pots are placed; that is, five in each of the two walls which form the two ſides of the furnace. Betwixt theſe walls there is a ſpace of fifteen or eighteen inches; which ſpace is covered by a vault reſting on the two walls. The whole forms a furnace ſeven feet long, two feet and a half high, open at one end, and ſhut at the other, excepting a ſmall chimney, through which the ſmoke paſſes.

Each of theſe pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the ſame ſize placed without the building, and pierced with a round hole in its baſe of fifteen or eighteen lines diameter. Laſtly, to each of theſe laſt mentioned pots there is a wooden tub placed below, in a bench made for that purpoſe.

Four or five of theſe furnaces are built under one hangar or ſhed. Fires are kindled in each of them at the ſame time; and they are thrown down after each diſtillation, either that the pots may be renewed, or that the reſiduums may be more eaſily taken out.

The fire being kindled in the furnace, heats the firſt pots containing the ſulphureous ſtones. The ſulphur riſes in fumes into the upper part of the pots whence it paſſes through the pipe of communication into the external veſſel. There the vapors are condenſed, become liquid, and flow through the hole below into the tub, from which the ſulphur is eaſily turned out, becauſe the form of the veſſel is that of a truncated cone, whoſe narrower end is placed below, and becauſe the hoops of the tub are ſo faſtened that they may be occaſionally looſened. The maſs of ſulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and caſt into rolls, ſuch as we receive it.

EXTRACTION *of* VITRIOL *from* PYRITES.

Sulphur is not the only ſubſtance procured from pyrites; for beſides that, different kinds of vitriols and alum, according to the nature of the pyrites, are alſo extracted: ſo that pyrites may be conſidered as the ores of vitriols and alum as well as of ſulphur.

Theſe ſalts do not exiſt in the pyrites ready formed, as the ſulphur does; but are, on the contrary, the products of the decompoſition of pyrites, and are new combinations reſulting from this decompoſition. In the pale-yellow martial pyrites, this decompoſition is effected without any other means than by expoſure to moiſture and air, and by the re-action of the ſulphureous principle upon the iron which the pyrites contains, and with which the acid of the ſulphur forms martial vitriol, as we may ſee under the article PYRITES. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and expoſed to the air during three years, till it has entirely fallen into powder; and it is then to be ſtirred up every ſix months to accelerate the efflorescence. The rain-water, which has waſhed it, is to be conducted into caldrons, into which old iron is thrown to ſaturate the ſuperfluous acid. After this ſucceeds the evaporation and cryſtallization.

It is not neceſſary that the pyrites ſhould fall into efflorescence for the extraction of vitriol. The action of the fire which decompoſes one part of the ſulphur produces the ſame effect. Thus, in the works at Schartzemberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the diſtillation of the ſulphur, which is called in ſome works, as we have before ſaid, the *burnings of ſulphur*, and which are in this work called *ſulphur-brands*. This operation conſiſts in impregnating well the lixivium with vitriol, by pouring it upon freſh parcels of theſe ſulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *ſulphur-caldron*; and afterwards it is cryſtallized in a wooden veſſel. The ſulphur-brands, from which vitriol has been extracted, are not thereby exhauſted; but they are expoſed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is alſo made at *Geyer*, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been uſed for the extraction of ſulphur by diſtillation, but has been roaſted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in ſhallow tubs called coolers, where it depoſites a yellow mud. The evaporation and depuration of this lixivium laſt twenty-four hours, and then the liquor is put into tubs to cryſtallize.

The pyrites, which has been roaſted and lixiviated once at Geyer, is not thereby exhauſted; but is made to undergo the ſame operation four or five times, by which it furniſhes more vitriol. The yellow mud which is depoſited from the lixivium is ſold, as a coloring material, to painters, after it has been calcined to redneſs.

Nature furniſhes a vitriol ready formed in ſome mineral earths, to obtain which vitriol, nothing but lixiviation is neceſſary. Such is that vitriol obtained at

Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpoſe of preparing aqua fortis, which is neceſſary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a ſoft rock and clay are found, containing vitriol, and which furniſh it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goſlar by the lixiviation of a mineral earth, compoſed of particles of different ores, found in the galleries of the mine at Rammelſberg, of which we have already ſpoken. The workmen call this ſubſtance the *ſmoke of copper*. It requires lixiviation only to furniſh vitriol. It is true, that by the wood-fires made in theſe galleries to calcine the rocks, the metallic matters may be diſengaged, and a part of the ſulphur burnt, the acid of which, mixing with the ſubterranean waters, diſſolves all the metallic matters it meets, and forms all kinds of vitriols. Nethertheleſs, ſome of theſe vitriolic waters, and even ſome cryſtallized vitriols, are found in theſe galleries, where no fire is ever made. The Germans call all theſe vitriols by the general name *Jockels*. Some vitriols are alſo found not cryſtallized, but forming various colored ſtones, which furniſh vitriol by lixiviation. They are called *ink-ſtones*. What is called *miſy* is a yellow, ſhining, vitriolic ſtone or earth, found in the ſame places.

To return to the ſubſtance called ſmoke of copper, whence the martial vitriol is extracted at Goſlar, ſeveral lixiviums are made of it, by pouring the ſame water upon different parcels of it: it is then made to evaporate, to depoſite its ſediment, and to cryſtallize, as we have already ſaid. The firſt water is called the *wild lie*. The ſeveral veſſels employed at Goſlar are named from their ſeveral uſes, as the *waſhing tub*, *mud tub*, &c.

This ſubſtance remaining after the lixiviation of this ſmoke of copper, is a kind of ore not entirely deprived of metallic ſubſtances. The workmen call the fineſt part of it *ſmall vitriol*, and the larger pieces they call *ſtones*, or *kernels of vitriol*. Both theſe are carried to the ſmelting-houſes to be roaſted and melted with the Rammelſberg ore, that the lead and ſilver, which they contain as well as that ore, may be extracted.

A white vitriol, whoſe baſis is zinc, is alſo procured at Goſlar from the ſame Rammelſberg ore. This vitriol was diſcovered in the year 1570 by the Duke Julian, who called it *alum of the mine*. At preſent it is known by the names, *white vitriol*, *vitriol of zinc*, *Goſlar vitriol*.

To make this vitriol, the ore of Rammelſberg, containing lead and ſilver, having been previouſly roaſted for the obtaining of ſulphur, as we have already deſcribed, undergoes the ſame operations which are practiſed for the preparation of martial vitriol, excepting the formation of large cryſtals, which is here purpoſely prevented, by liquefying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the cryſtallization of the vitriol. While the vitriol is liquefied, a part of the moiſture is evaporated, and women employed in this work keep ſtirring it till it has acquired the requiſite conſiſtence. By this ſtirring, it is divided into very fine cryſtalline particles, and it acquires the whiteneſs of the fineſt ſugar; a quality which makes it ſaleable, and which is procured by the means above related, and by carefully making it depoſite the ferruginous matter with which theſe lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from ſulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals alſo contain copper; and therefore the vitriol extracted from them is half martial and half cupreous, and is of a ſea-green color.

EXTRACTION *of* ALUM *from* PYRITOUS SUBSTANCES *and from* ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and ſulphureous minerals, is ſometimes of that kind of earths which are ſoluble in acids, and particularly of the nature of that earth which is the baſis of alum.

When the pyrites contains ſome of this kind of earth, the acid of its ſulphur being diſengaged either by the efflorefcence of the pyrites, or by its calcination and combuſtion, ought to unite itſelf as readily, and even more ſo, to this earth than to the metals contained in the ſame pyrites, and form a true alum: accordingly it ſo happens, and alum is extracted from pyrites or other ſulphureous minerals containing this earth, by proceſſes ſimilar to thoſe employed for the extraction of vitriols.

In England, a pyritous, ſlate-colored, ſulphureous ſtone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of foſſile alkali, diſſolved in water, is generally added.

The Swedes have a ſhining pyrites of a golden color, and ſpeckled with ſilvery ſpots, from which they extract ſulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have deſcribed; and when the lixivium yields no more cryſtals of vitriol, an eighth part of putrefied urine and lixivium of woodaſhes is added, by which a martial earth is precipitated: the liquor being poured off, cryſtals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from ſulphureous and metallic minerals, fine and pure cryſtals cannot be without ſome difficulty obtained. It is almoſt always neceſſary to have recourſe to ſome additions of alkaline matters, ſuch as quicklime, and fixed or volatile alkaline ſalts.

Theſe difficulties proceed partly from this, that different kinds of ſalts are formed at the ſame time by the decompoſition of theſe minerals; and that theſe ſalts are cryſtallized by nearly the ſame degrees of evaporation and cold. Hence a confuſion of ſalts muſt neceſſarily follow: and hence we do not find many of the vitriols, extracted from ſuch minerals, perfectly pure and free from alum, or from vitriolic ſalts with earthy baſes ſimilar to alum. The *ſals of colcothar* and the *gilla vitrioli* are nothing elſe than theſe foreign ſalts. On the other hand, the alum which is extracted from metallic minerals contains almoſt always ſome vitriol, and particularly martial vitriol. (k)

(k) From Mr. Margraaf's experiments, an addition of ſome alkaline ſubſtance ſeems to be always neceſſary to the formation of large cryſtals of alum, however free the lixivium is from the mixture of vitriols, or other ſalts. See a note (r) ſubjoined to the article ALUM (ROMAN).

But there are unmetallic earths and ſtones which contain alum, or its materials, ready formed: Such is that earth whence alum is extracted at Solfatara. This mineral is an earth ſimilar to marle in conſiſtence and color. It is gathered in the plain, and in the weſtern part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till theſe veſſels be three quarters full. The caldrons are ſunk ſo as to be almoſt level with the ground, under a great hangar or ſhed, at a diſtance of four hundred paces from the ſulphur furnaces. Into each caldron water is poured till it riſe three or four inches above the mineral. The heat of the ground in this place is ſufficient to warm the matter, as it makes Mr. Reaumur's thermometer riſe to 37½ degrees above the freezing point. By this means, without the expence of wood, the ſaline part is ſeparated from the earthy, and is obtained in large cryſtals.

Alum in this ſtate is ſtill mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is diſſolved by hot water in a great ſtone veſſel in form of a funnel. The purification of alum may be made ſo much more advantageouſly in this place, as no wood is neceſſary, the natural heat of the place being ſufficient for the proceſs.

To this kind of natural alum may be referred that which is obtained merely by evaporation from ſome mineral waters; and alſo the Roman alum which is obtained from a kind of free-ſtone, although a calcination during twelve or fourteen hours, and an expoſition to the air till it falls into efloreſcence be neceſſary. This ſtone is not pyritous, but rather of the marle kind: therefore its efloreſcence is probably nothing more than an extinction, and differs eſſentially from the efloreſcence of pyrites.

Such are the proceſſes by which ſulphur, vitriol, and alum are obtained from minerals containing theſe ſubſtances.

Theſe minerals contain a great quantity of vitriolic acid, which chemiſts can ſeparate from them; and they are, as it were, the grand magazines where nature depoſites this acid, which is always found combined, as we have ſeen, with ſome ſubſtance or baſis.

SMELTING *of* ORES *in general.*

As ores conſiſt of metallic matters combined with ſulphur and arſenic, and are beſides intermixed with earthy and ſtony ſubſtances of all kinds, the intention of all the operations upon theſe compound bodies is to ſeparate theſe different ſubſtances from each other. This is effected by ſeveral operations founded on the known properties of thoſe ſubſtances. We now proceed to give a general idea of theſe ſeveral operations.

Firſt of all, the ore is to be ſeparated from the earths and ſtones accidentally adhering to it; and when theſe foreign ſubſtances are in large maſſes, and are not very intimately mixed in ſmall particles with the ore, this ſeparation may be accompliſhed by mechanical means. This ought always to be the firſt operation, unleſs the adherent ſubſtance be capable of ſerving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this muſt neceſſarily be broken and divided into ſmall particles. This operation is performed by a machine which moves peſtles, called bocards, or ſtampers. After this operation, when the parts of the mineral are ſpecifically heavier than thoſe of the unmetallic earth or ſtone, theſe latter may be ſeparated from the ore by waſhing in canals through which water flows. With regard to this waſhing of ores, it is neceſſary to obſerve that it cannot ſucceed but when the ore is ſenſibly heavier than the foreign matters. But the contrary happens frequently, as well becauſe quartz and ſpar are naturally very ponderous, as becauſe the metallic matter is proportionably ſo much lighter as it is combined with more ſulphur.

When an ore happens to be of this kind, it is neceſſary to begin by roaſting it, in order to deprive it of the greateſt part of its ſulphur.

It happens frequently that the pyritous matters accompanying the ore are ſo hard that they can ſcarcely be pounded. In this caſe it is neceſſary to roaſt it entirely, or partly, and to throw it red-hot into cold water; by which the ſtones are ſplit, and rendered much more capable of being pulveriſed.

Thus it happens very frequently, that roaſting is the firſt operation to which an ore is expoſed.

When the ſubſtance of the ore is very fuſible, this firſt operation may be diſpenſed with, and the matter may be immediately fuſed without any previous roaſting, or at leaſt with a very ſlight one. For, to effect this fuſion, it is neceſſary that it retain a certain quantity of its ſulphur, which, with the other fluxes added, ſerves to deſtroy or convert into ſcoria a conſiderable part of the ſtoney matter of the mineral, and to reduce the reſt into a brittle ſubſtance which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore an intermediate matter betwixt the mineral and the metal; for the metal is there concentrated, and mixed with leſs uſeleſs matter than it was in the ore. But as this matt is always ſulphureous, the metal which it contains cannot have its metallic properties. Therefore it muſt be roaſted ſeveral times to evaporate the ſulphur, before it is remelted, when the pure metal is required. This fuſion of an ore not roaſted, or but ſlightly roaſted, is called *crude fuſion*.

We may here obſerve upon the ſubject of waſhing and roaſting of ores, that as arſenic is heavier than ſulphur, and has nearly the weight of metals, the ores in which it prevails are generally very heavy, and conſequently are ſuſceptible of being waſhed, which is a great advantage. But on the other ſide, as arſenic is capable of volatiliſing, ſcorifying, and deſtroying many metals, theſe ores have diſadvantages in the roaſting and fuſion, in both which conſiderable loſs is cauſed by the arſenic. Some ores contain, beſides arſenic, other volatile ſemi-metals, ſuch as antimony and zinc. Theſe are almoſt untractable, and are therefore neglected. They are called *minerae rapaces*, rapacious ores.

When the metal has been freed as much as is poſſible from foreign matters by theſe preliminary operations, it is to be completely purified by fuſions more or leſs frequently repeated; in which proper additions are made, either to abſorb the reſt of the ſulphur and arſenic, or to complete the vitrification or ſcorification of the unmetallic ſtones and earth.

Laſtly, as ores frequently contain ſeveral different metals, theſe are to be ſeparated from each other by proceſſes ſuited to the properties of theſe metals, of which we ſhall ſpeak more particularly as we proceed in our examination of the ores of each metal. (*l*)

(*l*) To facilitate the extraction of metallic ſubſtances from the ores and minerals containing them, ſome operations previous to the fuſion or ſmelting of theſe ores and minerals are generally neceſſary. Theſe operations conſiſt of, 1. The *ſeparation* of the ores and metallic matters from the adhering unmetallic earths and ſtones, by hammers, and other mechanical inſtruments; and by waſhing with water. 2. Their *diviſion* or reduction into ſmaller parts by contuſion and trituration, that by another waſhing with water they may be more perfectly cleanſed from extraneous matters, and rendered fitter for the ſubſequent operations, calcination or roaſting, and fuſion. 3. *Roaſting* or *calcination*, the uſes of which operation are, to expel the volatile, uſeleſs, or noxious ſubſtances, as water, vitriolic acid, ſulphur, and arſenic; to render the ore more friable and fitter for the ſubſequent contuſion, and fuſion; and, laſtly, to calcine and deſtroy the viler metals; for inſtance, the iron of copper-ores, by means of the fire, and of the ſulphur and arſenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red hot, and then extinguiſhed in cold water, that they may be rendered ſufficiently friable and pulverable, to allow the ſeparation of the metallic particles.

Roaſting is unneceſſary for native metals; for ſome of the richer gold and ſilver-ores; for ſome lead-ores, the ſulphur of which may be ſeparated during the fuſion; and for moſt calciform ores, as theſe do not generally contain any ſulphur and arſenic.

In the roaſting of ores, the following attentions muſt be given, 1. To reduce the mineral previouſly into ſmall lumps, that the ſurface may be encreaſed; but they muſt not be ſo ſmall, nor placed ſo compactly, as to prevent the paſſage of the air and flame. 2. The larger pieces muſt be placed at the bottom of the pile, where the greateſt heat is. 3. The heat muſt be gradually applied, that the ſulphur may not be melted, which would greatly retard its expulſion; and that the ſpars, fluors, and ſtones, intermixed with the ore, may not crack, fly and be diſperſed. 4. The ores not thoroughly roaſted by one operation muſt be expoſed to a ſecond. 5. The fire may be encreaſed towards the end, that the noxious matters more ſtrongly adhering may be expelled. 6. Fuel which yields much flame, as wood and foſſil coals free from ſulphur, is ſaid to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, theſe being very various according to the difference of the ores. A roaſting during a few hours or days is ſufficient for many ores; while ſome, ſuch as the ore of Rammelſberg, require that it ſhould be continued during ſeveral months.

Schlutter enumerates five methods of roaſting ores. 1. By conſtructing a pile of ores and fuel placed in alternate ſtrata, in the open air, without any furnace. *See* PLATE II. *Fig.* 11. *and Fig.* 12. 2. By confining ſuch a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace conſiſting of walls and a roof. 5. By roaſting the ore in a reverberatory furnace, in which it muſt be continually ſtirred with an iron-rod.

Several kinds of *fuſions of ores* may be diſtinguiſhed. 1. When a ſulphureous ore is mixed with much earthy matter, from which it cannot be eaſily ſeparated, by mechanical operations, it is frequently melted, in order to diſengage it from theſe earthy matters, and to concentrate its metallic contents. By this fuſion, ſome of the ſulphur is diſſipated, and the ore is reduced to a ſtate intermediate betwixt that of ore and of metal. It is then called a *matt* (*lapis ſulphureo-metallicus*), and is to be afterwards treated like a pure ore by the ſecond kind of fuſion, which is properly the *ſmelting*, or *extraction of the metal by fuſion*. 2. By this fuſion or ſmelting, the metal is extracted from the ore previouſly prepared by the above operations, if theſe be neceſſary. The ores of ſome very fuſible metals, as of biſmuth, may be ſmelted by

applying

OPERATIONS *on* ORES *of* NATIVE GOLD *and* SILVER, *by* WASHING *and by* MERCURY.

Earths and ſand are at firſt ſeparated by waſhing with water, by which operation the greateſt part of what is not gold, being lighter, is carried off. After this a ſecond waſhing is made with mercury, which having the property of uniting with gold, ſeizes this metal, amalgamates with it, and ſeparates it exactly from the earthy matters, with all which it can form no union.

applying a heat ſufficient only to melt the metals, which are thereby ſeparated from the adhering extraneous matters. This ſeparation of metals by fuſion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a compleat fuſion of the ore and vitrification of the earthy matters are neceſſary for the perfect ſeparation of the contained metals. By this method, metals are obtained from their ores, ſometimes pure, and ſometimes mixed with other metallic ſubſtances, from which they muſt be afterwards ſeparated; as we ſhall ſee, when we treat of the extraction of particular metals. To procure this ſeparation of metals from ores, theſe muſt be ſo thinly liquefied, that the ſmall metallic particles may diſengage themſelves from the ſcoria; but it muſt not be ſo thin as to allow the metal to precipitate before it be perfectly diſengaged from any adhering extraneous matter, or to pervade and deſtroy the containing veſſels and furnace. Some ores are ſufficiently fuſible; but others require certain additions called *fluxes*, to promote their fuſion, and the vitrification of their unmetallic parts; and alſo to render the ſcoria ſufficiently thin to allow the ſeparation of the metallic particles.

Different fluxes are ſuitable to different ores, according to the quality of the ore, and of the matrix, or ſtone adherent to it.

The matrixes of two different ores of the ſame metal frequently ſerve as fluxes to each other; as, for inſtance, an argillaceous matrix with one that is calcareous; theſe two earths being diſpoſed to vitrification when mixed, tho' each of them is ſingly unfuſible. For this reaſon, two or more different ores to be ſmelted are frequently mixed together.

The ores alſo of different metals require different fluxes. Thus calcareous earth is found to be beſt ſuited to iron-ores, and ſpars and ſcoria to fuſible ores of copper.

The fluxes moſt frequently employed in the ſmelting of ores are, calcareous earth, fluors or vitreous ſpars, quartz and ſand, fuſible ſtones, as ſlates, baſaltes, the ſeveral kinds of ſcoria, and pyrites.

Calcareous earth is uſed to facilitate the fuſion of ores of iron, and of ſome of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with feltſpar. This earth has been ſometimes added with a view of ſeparating the ſulphur, to which it very readily unites: but by this union, the ſulphur is detained, and a hepar is formed, which readily diſſolves iron and other metals, and ſo firmly adheres to them, that they cannot be ſeparated without more difficulty than they could from the original ore. This addition is therefore not to be made till the ſulphur be previouſly well expelled.

Fluors or *fuſible ſpars* facilitate the fuſion of moſt metallic minerals, and alſo of calcareous, and argillaceous earths, of ſteatites, aſbeſtus, and of ſome other unfuſible ſtones, but not of ſiliceous earths without a mixture of calcareous earth.

Quartz is ſometimes added in the fuſion of ferruginous copper ores, the uſe of which is ſaid chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous ſcoria.

The *fuſible ſtones*, as *ſlates*, *baſaltes*, are ſo tenacious and thick when fuſed, that they cannot be conſidered properly as fluxes, but as matters added to leſſen the too great liquidity of ſome very fuſible minerals.

The *ſcoria* obtained in the fuſion of an ore is frequently uſeful to facilitate the fuſion of an ore of the ſame metal, and ſometimes even of ores of other metals.

Sulphur and pyrites greatly promote the fuſibility of the ſcoria of metals, from the ſulphur it contains. It is chiefly added to

difficulty

The mercury thus charged with gold is preſſed through ſhamoy leather, and the gold is retained united with a part of the mercury, from which it may be eaſily diſengaged by expoſure to a proper degree of heat, which diſſipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. Theſe operations conſiſt in waſhings, triturations, and amalgams in the great by help of machines. We ſhall not enter into theſe details, becauſe they rather belong to mechanics than to chemiſtry. They who are deſirous to know them, may conſult a work written by Alonzo Barba on this ſubject.

The ores of native ſilver are much rarer and leſs abundant than thoſe of gold. But if any of this kind were found ſufficiently rich, they might be treated with mercury exactly in the ſame manner as the ores of native gold. (m)

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difficultly fuſible copper-ores, to form the ſulphureous compounds called *matts*, that the ores thus brought into fuſion may be ſeparated from the adhering earthy matters, and that the ferruginous matter contained in them may be deſtroyed, during the ſubſequent calcination and fuſion, by means of the ſulphur.

As in the ores called *calciform*, the metallic matter exiſts in a calcined ſtate; and as calcination reduces the metals of mineraliſed ores (excepting the perfect metals) to that ſtate alſo; therefore all calciform and calcined ores require the addition of ſome *inflammable ſubſtance*, to furniſh them with the phlogiſton neceſſary for their reduction to a metallic ſtate. In great works, the charcoal or other fuel uſed to maintain the fire produces alſo this effect.

Metals are ſometimes added in the fuſion of ores of other more valuable metals, to abſorb from theſe ſulphur or arſenic. Thus iron is added to ſulphurated, cupreous, and ſilver ores. Metals are alſo added in the fuſion of ores of other more valuable metals, to unite with and collect the ſmall particles of theſe diſperſed through much earthy matter, and thus to aſſiſt their precipitation. With theſe intentions, lead is frequently added to ores and minerals containing gold, ſilver, or copper.

Ores of metals are alſo ſometimes added to aſſiſt the precipitation of more valuable metals. Thus antimony is frequently added to aſſiſt the precipitation of gold intermixed with other metallic matters. See *purification of gold by antimony*. Thus far of ſmelting of ores in general.

(m) Gold is frequently contained in the ores of other metals, either in a native or mineraliſed ſtate, and in ſands, eſpecially thoſe which are black and ferruginous. *See* ORES *of* GOLD.

If *gold be contained in ores of other metals*, theſe metals together with the gold may be firſt extracted by the ordinary proceſſes for ſmelting theſe ores; and the gold may be then ſeparated from the metallic maſs thus obtained, by mixing and fuſing this maſs with a quantity of lead, and by the proceſs of cupellation, deſcribed in the articles ESSAY *of the* VALUE *of* SILVER, *and* REFINING. Generally, the operations for obtaining gold from ores of imperfect metals are preciſely the ſame as thoſe for obtaining ſilver, to which therefore we refer. Moſt frequently a quantity of ſilver alſo is contained in theſe ores; and in this caſe the perfect metal obtained by cupellation is an allay of gold and ſilver, which muſt be afterwards ſeparated by the proceſſes called *parting*. *See* PARTING.

Many trials have been made to procure the ſmall quantity of gold contained in the *ferruginous ſands*, at a moderate expence (*See* ORES *of* GOLD); but as no work of this kind is now eſtabliſhed, we may preſume they have not been ſucceſsful. The beſt eſſays of this kind have been made, according to Schlutter, in the following manner.

The ſand is to be made red-hot, and extinguiſhed in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddiſh brown. It is obſerved to emit, during the firſt and ſecond calcinations, an arſenical ſmell; and this ſmell may be produced again in the following calcinations by adding ſome inflammable matter. Let an ounce of the calcined ſand be mixed with two ounces of

SMELTING *of* ORES *of* SILVER.

As ſilver, even in its proper ores, is always allayed with ſome other metals from which it is intended to be ſeparated, after that the ſilver ore has been well roaſted, it muſt be mixed with a greater or leſs quantity of lead previous to its fuſion.

Lead has the ſame effect in fuſion of gold and ſilver as mercury has upon theſe metals by its natural fluidity; that is to ſay, it unites with them, and ſeparates them from unmetallic matters, which, being lighter, riſe always to the ſurface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic ſubſtances, excepting gold and ſilver. Hence it follows, that when gold and ſilver are obtained by means of mercury, they ſtill remain allayed with other metallic ſubſtances; whereas when they are obtained by fuſion and ſcorification with lead, they are then pure, and are not allayed with any metals but with each other.

In proportion as the lead, which has been united to the gold and ſilver of the ore, is ſcorified by the action of the fire, and promotes the ſcorification of the other metallic matters, it ſeparates the perfect metals, and carries with it all the others to the ſurface. There it meets the unmetallic ſubſtances, which it likewiſe vitrifies, and which it changes into a perfect ſcoria, fluid, and ſuch as a ſcoria ought to be to admit all the perfect metal contained in it to precipitate.

When all heterogeneous matters have been thus diſengaged by ſcorification with lead, the perfect metals, to which ſome lead ſtill remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fuſion and ſcorification of ſilver ore with lead, is to add to the ore a quantity of lead ſo much greater as there is more matter to be ſcorified, and as theſe matters are more refractory and of more difficult fuſion. Silver ores, or thoſe treated as ſuch, are often rendered refractory by ferruginous

granulated lead, and one ounce of black flux, and put into a Heſſian crucible, with half an ounce of decrepitated ſea-ſalt upon the ſurface of the mixture. The crucible is to be placed in a good blaſt furnace, and a ſtrong fire is to be excited. The matter contained in the crucible is to be frequently ſtirred with an iron-rod, and the heat is to be continued till the ſcoria is thin and perfectly fuſed. When the crucible is broken, a regulus of lead will be found, containing the gold and ſilver of the ſand. By this method Mr. Leberecht obtained, in eleven eſſays, from 840 to 844 grains of perfect metal from a quintal of ſand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of ſand have yielded more than a thouſand grains, and ſome not more than 350 grains per quintal. Inſtead of the granulated lead, and the black flux, which is too expenſive for great operations, ſome have added, to an ounce of the ſand, two ounces of litharge and a little powder of charcoal, by which they have obtained the ſame quantity of perfect metal. The ſcoria in theſe eſſays has been always found to contain ſome perfect metal.

The Hungarian copper ores, from which gold and ſilver are profitably extracted, contain a leſs quantity of theſe perfect metals than many ferruginous ſands. But they may be formed into a matt, by fuſion with pyrites, of which treatment the ſands are incapable. From this matt, the gold and ſilver, along with the copper of the ore, may be precipitated, and ſeparated from the ſulphur of the pyrites, by addition of iron, which being more diſpoſed than the other metals to unite with ſulphur, diſengages theſe metals, and allows them to precipitate.

earths, pyritous matters, or cobalts, containing always a conſiderable quantity of an earth which is unmetallic, very ſubtle, and very refractory, and which renders a conſiderable augmentation of the quantity of lead neceſſary.

The quantity of lead which is commonly added to fuſible ſilver-ores, that do not contain lead, is eight times the quantity of the ore. But when the ore is refractory, it is neceſſary to add twelve times the quantity of lead, and even more; alſo glaſs of lead, and fluxes, ſuch as the white and black fluxes; to which however borax and powder of charcoal are preferable, on account of the liver of ſulphur formed by theſe alkaline fluxes.

It is neceſſary to obſerve, that ſaline fluxes are only uſed in ſmall operations, on account of their dearneſs. To theſe are ſubſtituted, in the great operations, of which we now treat, ſandiver, fuſible ſcoria, and other matters of little value.

The greateſt part of the ſilver now employed in commerce is not obtained from the proper ores of ſilver, which are very ſcarce, but from lead, and even copper-ores, which are more or leſs rich in ſilver. To give an idea of the manner of treating theſe kinds of ores, from which ſilver is extracted in the great works, we ſhall briefly deſcribe here, after Schlutter, the ſmelting of the ore of Rammelſberg, which contains, as we have already ſaid, ſeveral different kinds of metals, but particularly lead and ſilver.

When this mineral has been diſengaged from its ſulphur as much as poſſible, by three very long roaſtings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for ſmelting upon a hollow or *caſſe*. *See* PLATE II. *Fig.* 13. The maſonry of this furnace is compoſed of large, thick ſlates, capable of ſuſtaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only in the front. Its height is nine feet eight inches. It has a foundation of maſonry in the ground; and, in this foundation channels are made for the evaporation of the moiſture. Theſe channels are covered over with ſtones called *covering ſtones*. The hollow or caſſe, which is made above theſe, is formed of bricks, upon which are placed, firſt, a bed of clay; then a bed of ſmall ore and ſifted vitriols; and, laſtly, a bed of charcoal-powder beat down, called *light braſque*. The anterior wall of the furnace is thinner than the others, and is called the *chemiſe*. The back wall, which is pierced to give paſſage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or caſſe; which being kindled, the fire is to be continued during three hours, before the matters to be fuſed are added. Then theſe matters are thrown in, which are not the pure ore, but a mixture of ſeveral ſubſtances, all of which are ſomewhat profitable. The quantity of theſe matters is ſufficient for one day's work; that is for a fuſion of eighteen hours; and it conſiſts of; 1. Twelve ſchorbens or meaſures of well roaſted Rammelſberg ore; (the ſchorben is a meaſure whoſe contents are two feet five inches long, one foot ſeven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologn weight, at 123 pounds each quintal). 2. Six meaſures of ſcoria produced by the ſmelting of the ore of Upper Hartz, which is refractory, and what workmen call *cold*. 3. Two meaſures of *knobben*, which is an impure ſcoria containing ſome lead and ſilver, which has been formerly thrown away as uſeleſs, and is now collected by women and children. Beſides theſe, other matters are added, containing lead and ſilver, as the teſts employed in refining, the droſs of lead, impure litharge, and any rubbiſh containing metal, which was left in the furnace after the foregoing fuſion. All theſe matters being mixed together are thrown into the furnace: And to each meaſure of this mixture a meaſure of charcoal is added. The fuſion is then begun by help of bellows; and as it proceeds, the lead falls through the light braſque or charcoal bed, into the hollow, or caſſe, where it is preſerved from burning under the powder of charcoal. The ſcoria, on the other hand, being lighter and leſs fluid, is ſkimmed off from time to time by means of laddles, that it may not prevent the reſt of the lead from falling down into the hollow. Thus, while the fuſion laſts, freſh matters and freſh charcoal are alternately added, till the whole quantity intended for one fuſion, or, as they call it, one *day*, be thrown in.

There are ſeveral eſſential things to be remarked in this operation, which is very well contrived. Firſt, the mixture of matters from which a little lead and ſilver is procured, which would otherwiſe be loſt; and which have alſo this advantage, that they retard the fuſion of the Rammelſberg ore, which, however well roaſted it has been, retains always enough of the ſulphur and iron of the pyrites mixed with it, to render it too fuſible or too fluid, ſo that without the addition of thoſe matters, nothing would be obtained but a matt. It is even neceſſary, notwithſtanding theſe additions, not to haſten the fuſion too much, but to give time for the ore to mix with the other matters, elſe it would melt and flow of itſelf before the reſt. Secondly, the fuſion of the ore through charcoal, which is practiſed in moſt ſmelting-houſes and for almoſt all ores, is an excellent method, the principal advantage of which is the ſaving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the ſame time that it melts it more readily and effectually, alſo ſupplies it with the phlogiſton neceſſary to bring it to a perfect ſtate.

We mentioned, when treating of vitriols obtained from the Rammelſberg ore after its firſt roaſting, that a *white vitriol* was alſo obtained, and prepared at *Goſlar*, whoſe baſis was *zinc*: which proves that this ore contains alſo a certain quantity of this ſemi-metal. As this ore is ſmelted in a country where the art is well underſtood of extracting every thing which a mineral contains, ſo in this fuſion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fuſion; it is neceſſary to cloſe it up in the fore-part, before the fuſion is begun.

"First of all, a gritt-ſtone is to be placed, ſupported at the height of three "inches. This ſtone is as long as the furnace is broad, and the height of it "is level with the hole where the bellows pipe enters. It is faſtened on each ſide "of the furnace, externally and internally, with clay. Upon this ſtone a kind "of receptacle, or, as it is called, the *ſeat of the zinc*, is made in the following "manner. A flat, ſlaty ſtone is choſen, likewiſe as long as the furnace is "broad, and eight inches in breadth. This is placed on the gritt-ſtone above-"mentioned, in ſuch a manner, that it inclines conſiderably towards the front "of the furnace, and that its bottom touches cloſely the gritt-ſtone. It is "faſtened with clay, which is alſo laid upon the ſeat of the zinc. Upon this ſeat, "which is to receive the zinc, two round pieces of charcoal are placed, and upon

" theſe a ſtone, called the *zinc ſtone*, reſts, which is about a foot and a half " in length, and cloſes one part of the front of the furnace. This ſtone alſo " is faſtened on each of its ſides with clay. Clay is likewiſe put under the " ſtone betwixt the two pieces of charcoal, which hinder it from touch- " ing the ſeat of the zinc. The under part of this ſtone is but ſlightly luted, " that the workmen may make an opening for the zinc to flow out. Thus " is made the ſeat or receptacle of the zinc to detain this metallic ſubſtance, " which would otherwiſe fall into the hotteſt part of the fire, called by the " workmen the melting place, and would be there burnt: whereas it is " collected upon this receptacle during the fuſion, where it is ſheltered from " the action of the bellows, and conſequently from too great heat.

" When all the matter to be fuſed in one day is put into the furnace, the " blaſt of air is continued till that matter has ſunk down. When it is half way " down the furnace, they draw out the ſcoria, that more of the ore and other " matters may be expoſed to the greateſt heat. As ſoon as the ſcoria is cooled " and fixed a little, two ſhovel-fulls of ſmall wet ſcoria or ſand is thrown cloſe " to the furnace, and beat down with the ſhovel; then the workmen open " the ſeat or receptacle of zinc, and ſtrike upon the zinc-ſtone to make the " ſemi metal flow out. As ſoon as the pureſt part of it has flowed out, it " is ſprinkled with water and carried away. Then the workmen ſeparate entirely " the zinc-ſtone from the wall of the furnace, and they continue to give it little " ſtrokes, that the ſmall particles of zinc diſperſed among the charcoal may " fall down. This being done, the ſtone is removed, and the zinc is " ſeparated from the charcoal by an iron inſtrument, is cleaned, and remelted " along with the zinc that flowed out at firſt, and is caſt into round cakes. " The reaſon why the zinc is withdrawn before the bellows ceaſe to blow, is, " that if it was left till the charcoal on the ſeat or receptacle was conſumed, it " would be moſtly burnt, and little would be obtained. Thus after the zinc fuſion is finiſhed by blowing the bellows till the end."

Thus the zinc is ſeparated from the ore of Rammelſberg, and is not confounded in the matte or caſſe with the lead and ſilver, becauſe being a volatile ſemi-metal, it cannot ſupport the activity of the fire without riſing into vapors, which are condenſed in the place leaſt hot, that is to ſay, upon the ſtones expreſsly prepared for that purpoſe, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is alſo in this furnace, and after the fuſion of the Rammelſberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is compoſed of ſulphureous and ferruginous pyrites, of true lead ore containing ſilver, and a very hard and compact matter of a dark browniſh-grey color, which is probably a lapis calaminaris, or an ore of zinc. Theſe ſeveral matters of the Rammelſberg ore are not ſeparated from each other, either for the roaſting or for the fuſion. Thus there zinc in all the parts of the roaſted ore, and much more of it would be obtained, if it was not ſo eaſily inflammable. All the zinc which is obtained is preſerved from burning by falling, while in fuſion, behind the chemiſe or forepart of the furnace, which is, as has been ſaid, a kind of ſchiſtus or ſlate, called by the workmen *ſteel ſtone*. But the part of this ſemi-metal which falls in the middle of the furnace, near the middle wall, or towards the ſides, being expoſed to the greateſt heat of the fire, is there burnt; and its ſmoke or flowers attaching itſelf on all ſides to the walls of the furnace, undergo there a ſemi-fuſion, which renders this matter ſo hard and ſo thick that it muſt be taken away after every fourth fuſion, or, at moſt, after every ſixth fuſion. That which is found attached to the higheſt part of the furnace is the beſt and pureſt. The reſt is altered by a mixture of a portion of lead which it has carried up with it, and which from its great weight and fixity has hindered the zinc from riſing ſo high as it would have done alone. Therefore with this kind of impure cadmia ductile braſs cannot be made.

Almoſt all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelſberg ore, by the proceſs deſcribed, and conſequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fuſed for that purpoſe. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of braſs, a convenient proceſs for extracting zinc from it was not known, becauſe when treated by fuſion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fuſed without a very violent fire; and alſo from the volatility and combuſtibility of the zinc, which for this reaſon cannot be collected at the bottom of a crucible, as a regulus under a ſcoria, like moſt metals.

M Margraaf has remedied theſe inconveniences by diſtilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing ſome water, and conſequently in cloſe veſſels, where the zinc by the help of a very ſtrong fire indeed, is ſublimed in its metallic form without burning. He alſo by the ſame method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is alſo a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiſton. But it is evident that ſuch operations as theſe are rather fit to ſupply proofs for chemical theory, than to be put in practice for works in great (*n*). M. Margraaf has obſerved, that the zinc which he obtained by this proceſs was leſs brittle than what is obtained from the fuſion of ores; which may proceed from its greater purity, or from its better combination with phlogiſton.

After this digreſſion which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not inſert elſewhere, becauſe of the neceſſary relation it has with the ſmelting of the Rammelſberg ore, we proceed to the other operations of the ſame ore, that is to ſay, to the *finery*, by which the ſilver is ſeparated from the lead, which are mixed together, forming what is called the *work*.

(*n*) Zinc is obtained not only in the method uſed at Goſlar above-deſcribed, but is alſo extracted in great works from lapis calaminaris and calcined blend, by a diſtillation ſimilar to that by which Mr. Margraaf has eſſayed ores of zinc. The firſt work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this ore, when calcined, powdered, and mixed with charcoal, was put into iron or ſtone retorts, and the zinc was obtained by diſtillation. In Briſtol a work is eſtabliſhed in which zinc is obtained by a diſtillation *by deſcent*. See a ſection and deſcription of the furnace and apparatus employed. Plate II. *Fig.* 22. and *explanation*.

This operation differs from the fining of eſſay, or in ſmall, principally in this circumſtance, that in the latter method of fining, all the litharge is abſorbed into the cupel, whereas in the former method the greateſt part of this litharge is withdrawn.

The fining in great of the work of Rammelſberg is performed in a furnace called a *reverberatory furnace.* This furnace is ſo conſtructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air (which is introduced through the aſh-hole, and which goes out at an opening on one ſide of that part of the furnace where the work that is the lead and ſilver are) to circulate above, and to give the convenient degree of heat, when the fire is properly managed In this furnace a great cupel, called a *teſt*, is diſpoſed. This teſt is made of the aſhes of beech-wood, well lixiviated in the uſual manner. In ſome foundaries different matters are added, as ſand, ſpar, calcined gypſum, quicklime, clay. When the teſt is well prepared and dried, all the work is put at once upon the cold teſt, to the quantity of ſixty-four quintals for one operation. Then the fire is lighted in the fire-place with faggots, but the fuſion is not urged too faſt; 1. That the teſt may have time to dry: 2. Becauſe the work of the Rammelſberg ore is altered by the mixture of ſeveral metallic matters, which it is proper to ſeparate from it, otherwiſe they would ſpoil the litharge and the lead procured from it. Theſe metallic matters are, copper, iron, zinc, and matt. As theſe heterogeneous ſubſtances are hard and refractory, they do not melt ſo ſoon as the *work*, that is, as the lead and ſilver; and when the work is melted, they ſwim upon its ſurface like a ſkin, which is to be taken off. Theſe impurities are called the *ſcum*, or the *firſt-waſte.* What remains forms a ſecond ſcum, which appears when the work is at its greateſt degree of heat, but before the litharge begins to form itſelf. It is a ſcoria which is to be carefully taken off. It is called the *ſecond waſte.*

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very ſurface of the metal, by means of iron plates put for that purpoſe before the blaſt-hole, which are called *papillons.* This blaſt does not ſo much encreaſe the intenſity of the fire, as it facilitates the combuſtion of the lead, and throws the litharge that is not imbibed by the teſt towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace: the matter which is found in the middle of the largeſt pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like ſand. This is put into barrels containing each five quintals of it, and is called ſaleable litharge, becauſe it is ſold in that ſtate. The other part which remains ſolid is called *cold litharge*, and is again melted and reduced into lead. The fuſion is called *cold fuſion*, and the lead obtained from it, *cold lead*, which is good and ſaleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The teſts and cupels impregnated with litharge are added in the fuſion of the ore, as we have already related.

When two thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The ſilver then appears covered with a white ſkin, which the finers call *lightening*, and the metal, *lightened* or *fined ſilver*.

The ſilver obtained by this proceſs of fining is not yet altogether pure. It ſtill contains ſome lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who compleat its purification by the ordinary method. This laſt operation is the *refining*, and the workmen employed to do it are called *refiners*. A fining of ſixty four quintals of *work*, yields from eight to ten marcs of fined ſilver, and from 35 to 40 quintals of litharge; that is, from 12 to 18 of ſaleable litharge, from 22 to 23 of cold litharge, from 20 to 22 quintals of impregnated teſt, and from ſix to ſeven quintals of lead-droſs. The operation laſts from 16 to 18 hours. (*o*)

(*o*) Ores containing ſilver may be divided into four kinds; 1. *Pure*, or thoſe which are not much compounded with other metals. 2. *Galenical*, in which the ſilver is mixed with much *galena* or ore of lead mineraliſed by ſulphur. 3. *Pyritous*, in which the ſilver is mixed with the martial pyrites. 4. *Cupreous*; in which the ſilver is contained in copper-ores. To extract the ſilver from theſe ſeveral kinds of ores, different operations are neceſſary.

Native ſilver is ſeparated from its adhering earths and ſtones by amalgamation with mercury, in the manner directed for the ſeparation of gold; or by fuſion with lead, from which it may be afterwards ſeparated by cupellation.

Pure ores ſeldom require a previous calcination, but, when bruiſed and cleanſed from extraneous matters, may be fuſed directly, and incorporated with a quantity of lead; unleſs they contain a large proportion of ſulphur and arſenic; in which caſe a calcination may be uſeful. The lead employed muſt be in a calcined or vitrified ſtate, which, being mixed with the ore, and gradually reduced by the phlogiſton of the charcoal added to it, may be more effectually united with the ſilver of the ore, than if lead itſelf had been added, which would too quickly precipitate to the bottom of the containing veſſel or furnace. The ſilver is to be afterwards ſeparated from the lead by cupellation.

Galenical ores, eſpecially thoſe in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fuſed together with ſome inflammable matter, as charcoal, by which the lead is revived, and, together with the ſilver, is precipitated.

Pyritous ores muſt be firſt melted, ſo as to form a matt. If the ſulphur is not ſufficient for this kind of fuſion, more ſulphurated pyrites may be added. This matt contains, beſides ſilver and ſulphur, alſo various metals, as lead, iron, and ſometimes cobalt. The matt muſt be expoſed to repeated calcinations till the ſulphur is diſſipated. By theſe calcinations moſt of the iron is deſtroyed. The calcined matt is to be fuſed with litharge, and the ſilver incorporated with from the other imperfect metals with which it may be mixed, it muſt afterwards be ſeparated by cupellation. *See* REFINING.

The ſilver contained in *cupreous ores* may be obtained, either, 1. By ſeparating it from the copper itſelf, after this has been extracted along with the ſilver, in the uſual manner, from the ore; or, 2. By precipitating it immediately, from the other matters of the ore.

1. It may be ſeparated from the copper by two methods. One of theſe is by adding lead, and ſcorifying the imperfect metals. By this method much of the copper would be deſtroyed, and it is therefore not to be uſed unleſs the quantity of ſilver relatively to the copper be conſiderable. Another method by which ſilver may be ſeparated from copper is, by *eliquation*; that is, by mixing the maſs of copper and ſilver with a quantity of lead, and applying ſuch a heat as ſhall be juſt ſufficient to make the lead eliquate from the copper, together with the ſilver, which being more ſtrongly diſpoſed to unite with the lead than with the copper, is thus incorporated with the former metal, and ſeparated

SMELTING *of* ORES *of* COPPER.

The ſmelting in great of copper ores, and even of ſeveral ores of ſilver and lead, excepting that of Rammelſberg, is performed in furnaces not eſſentially different from that already deſcribed; but in this reſpect only, that the ſcoria and metal are not drawn out of the furnace, but flow ſpontaneouſly, as ſoon as they are melted, into *receiving baſons*, where the metal is freed from the ſcoria. Theſe furnaces are generally called *pierced furnaces.*

Inſtead of a light braſque, or bed of charcoal-powder, under which the metal lies hid, the bottom of theſe furnaces is covered with a baſon compoſed of heavy braſque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemiſe, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving baſons*, made of earth, ſcoria, ſand, &c. There the metal is ſeparated from the ſcoria, by making it flow from theſe baſons into another lateral one. Theſe furnaces are alſo called *crooked furnaces.*

Different names are given to them according to ſome difference in their conſtruction. For inſtance, thoſe which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two baſons, are called *ſpectacle-furnaces.* Their greater or leſs height gives occaſion alſo to the diſtinction of *high furnaces*, and *middle furnaces.*

The high furnaces are of modern invention. They were firſt introduced at Mansfeldt in the year 1727, and they are now uſed in almoſt all countries where ores are ſmelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage conſiſts in ſimplifying and diminiſhing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hotteſt part of the fire, and is melted. Conſequently, it ſuffers ſucceſſively different degrees of heat, and, before it is melted, it undergoes a roaſting which coſts nothing; therefore the high furnaces

rated from the latter. *See the article* ELIQUATION.

2. Silver may alſo be extracted from theſe cupreous ores by *precipitation*. For this purpoſe, let the ores, previouſly bruiſed and cleanſed, be formed into a matt, that the earthy [illegible] be well ſeparated. Let the matt [illegible] with a ſtrong heat; and when [illegible] has been removed, and the heat is [illegible], add to it ſome clean galena, litharge [illegible]. When the fire [illegible] well incorporated [illegible] caſt [illegible] iron [illegible] maſs, which [illegible] lead is to unite with ſulphur, will ſeparate and precipitate the latter metal; and along with it the ſilver or gold contained in the matt. This method was introduced by Scheffer, and is practiſed at Adelfors in Smoland. In this work the proportion of the ſeveral materials is, four quintals of matt, two quintals of black copper containing ſome lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of caſt iron.

The ſilver in this, and in all other inſtances where it is united with lead, is to be afterwards ſeparated from the lead by cupellation; which proceſs is deſcribed at the article ESSAY *of the* VALUE *of* SILVER, *and* REFINING.

are chiefly employed for crude fuſions, and particularly for the ſlate copper-ore. Theſe furnaces are above eighteen feet high. A too great height is attended with an inconvenience, beſides the trouble of ſupplying it with ore and fuel, which is, that the charcoal is moſtly conſumed before it gets down where the greateſt heat is required, and is then rendered incapable of maintaining a fire ſufficiently intenſe.

All the furnaces which we have mentioned are ſupplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for ſmelting ores where bellows are not employed, is what is called a *reverberatory furnace*. The Germans call it a *wind-furnace*. It is alſo diſtinguiſhed by the name of *Engliſh furnace*, becauſe the invention of it is attributed to an Engliſh phyſician of the name of *Wright*, who was well verſed in chemiſtry; and becauſe the uſe of it was firſt introduced in England about the end of the laſt century, where it is much employed, as well as in ſeveral other countries, as at Konigſberg, in Norway. *See* PLATE II. *fig.* 14 and 15.

The length of theſe furnaces is about eighteen feet, comprehending the maſonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raiſed three feet above the level of the foundery: on one ſide is the fire-place, under which is an aſh-hole hollowed in the earth; on the other ſide is a baſon made, which is kept covered with fire when there is occaſion: on the anterior ſide of this furnace there is a chimney, which receives the flame after it has paſſed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of a clay capable of ſuſtaining the fire. The advantage of this furnace is, that bellows are not neceſſary, and conſequently it may be conſtructed where there is no current of water, and wherever the mine happens to be. This furnace has a hole in its front through which the ſcoria is drawn out; and a baſon, as we have ſaid, on one ſide, made with ſand, in which are oblong traces for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineraliſed, not only by ſulphur and arſenic, but alſo by ſemimetals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with ſulphur and arſenic, it is almoſt impoſſible to diſengage it from them entirely by roaſting; hence in the ſmelting in great, nothing is obtained by the firſt operation but a copper-matt, which contains all the principles of the ore, excepting the earthy and ſtony parts, particularly when the ore is ſmelted crude and unroaſted. Afterwards this matt muſt be again roaſted and fuſed. The product of this ſecond fuſion [illegible] ſtill more to reſemble copper, but is not malleable [illegible] almoſt all the minerals, particularly [illegible] a black color, it is always called [illegible] ever its color happens really to be.

As, of all the imperfect metals, copper is moſt difficultly burnt [illegible] it is again roaſted ſeveral times, in order to burn [illegible] ſtances mixed with it, and this [illegible] till the copper [illegible] is then called [illegible] and refining of it [illegible] of theſe happened to be in [illegible]

In order to avoid all these fusions, it has been proposed to treat in the humid way certain copper ores, particularly those which are very pyritous. This method consists in making blue vitriol from the ore, by roasting and lixiviating it, and in precipitating pure copper from this lixivium, which is called *cement-water*, by means of iron; but it is not much practised, because it has been observed, that all the copper contained in the ore was not procured by this means.

As copper is not much regarded in small assays and experiments, these fusions are much abridged and facilitated by adding at first saline and glassy fluxes, and then by refining the black copper with lead in the cupel, as gold and silver are done. In this method of refining it is to be most carefully observed, that the metal be fused as quickly as possible, and exposed to no more heat than is necessary, lest it be calcined.

When the black copper contains some iron, but not a great deal, the lead presently separates the iron from it, and makes it rise to the surface of the copper; but if the iron be in too large a proportion, it prevents the lead from uniting with the copper. These two phenomena depend on the same cause, which is, that lead and iron cannot unite.

Frequently copper ores contain also a quantity of silver sufficient to make its extraction by particular processes profitable. It was long before any process could be thought of for this purpose which was not too expensive and troublesome; but at length it was accomplished by the excellent operation, called *eliquation*. See the word ELIQUATION.

The copper from which silver has been separated by eliquation must be refined after this operation, as it is generally black copper from which silver is extracted; but even if it had not been black copper which was employed for this operation, it would require to be refined on account of a little lead it always retains. It is accordingly carried to the refiners furnace, where this operation is performed by help of bellows, the blast of which is thrown upon the surface of the melted metal. As in this refining of copper the precise time when it becomes pure cannot be known, because scoria is always formed on its surface, it is necessary to use an *essay-iron*, the polished end of which being dipt in melted copper, shows that the metal is pure when the copper adhering to the [illegible] in cold water.

When this mark of the purity of the copper has been observed, its surface [illegible] cleaned, and as soon as it begins to [illegible] it must be sprinkled with [illegible] in cold water. The surface of the copper which is [illegible] cooled by the water, detaches itself from the rest of the [illegible] and is thrown into cold water: [illegible] of copper is [illegible] reduced into [illegible] and these plates are what is called *rosette copper*.

[illegible]

[illegible] and roastings are [illegible] till [illegible] These methods [illegible] copper ores, depend on the two following facts: 1. Sulphur is more disposed to unite with iron than with copper.

2. The

We ſhall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended

2. The iron of theſe ores is deſtructible by the burning ſulphur during the roaſting or the fuſion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of ſmelting cupreous ores.

From theſe facts we learn, 1. That ſulphur may be employed to ſeparate and deſtroy iron mixed with copper; 2dly, that iron may be employed to ſeparate the ſulphur from copper, as is ſometimes done in the eſſay of ſulphurated copper-ores; and, 3dly, that by adjuſting the proportion of the iron and ſulphur to each other in the ſmelting of copper-ores, theſe two ſubſtances may be made to deſtroy each other, and to procure a ſeparation of the copper; and this adjuſtment may be effected, by adding ſulphur or ſulphureous pyrites to the copper-ore, when the quantity of ſulphur contained in this ore relatively to the iron is too ſmall; or by adding iron when the ſulphur predominates; or by roaſting, by which the ſuperfluous ſulphur may be expelled, and no more left than is ſufficient for the deſtruction of the iron contained in the ore. We ſhall apply theſe principles to the following caſes.

1. When the quantity of ſulphur and of iron in a copper-ore is ſmall, and eſpecially when the iron does not too much abound, a previous roaſting will at once calcine the iron, and expell moſt of the ſulphur; ſo that by one fuſion the calcined iron may be ſcorified, and black copper may be obtained. If the ſulphur has not been ſufficiently expelled, a ſecond roaſting and fuſion are requiſite; for the whole quantity of ſulphur ought not to be expelled during the firſt roaſting; but as much ought to be left as is ſufficient for the ſcorification of the calcined iron, otherwiſe this might, during the fuſion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the ſulphur, ſome ſulphurated pyrites, eſpecially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and ſcorified.

3. When the quantity of ſulphur and iron is very great, that is, when the ore is very pyritous and poor, it ought to be firſt formed into a matt; by which it is ſeparated from the adherent earths and ſtones, and the bulk is diminiſhed; then, by repeated and alternate roaſtings and fuſions, the copper may be obtained.

4. When the quantity of ſulphur in an ore is greater than is ſufficient for the forming a matt, the ſuperfluous quantity ought to be previouſly expelled by roaſting.

The copper thus at firſt obtained is never pure, but is generally mixed with ſulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a ſmall quantity of lead is added, which unites with the ſulphur, and is ſcorified together with the iron, and floats upon the ſurface of the melted copper. This purification of copper by means of lead is ſimilar to the refining of ſilver by cupellation, and is founded on the property of lead, by which it is more diſpoſed to unite with ſulphur than copper is, and on a property of copper, by which it is leſs liable than any other imperfect metal to be ſcorified by lead. But as copper is alſo capable of being ſcorified by lead, this operation muſt be no longer continued, and no more lead muſt be employed than is ſufficient for the ſeparation of the ſulphur, and for the ſcorification of the iron.

The copper might alſo be purified from any remaining ſulphur by adding a ſufficient quantity of iron to engage the ſulphur. Thus Mr. Scheffer found, that by adding to ſulphurated copper from [illegible] to [illegible] of old caſt iron, he rendered the cop[illegible] ductile. *See his Diſſertation in* [illegible] [illegible] year 1752. [illegible] quantity of iron added ought not to be too little, elſe all the ſulphur will not be ſeparated; and it ought not to be too great, elſe the ſuperfluous quantity will unite with and injure the [illegible] of the copper. The fuſion and ſcorification, with addition of lead, ſeems to be the beſt method for the laſt purification of copper.

for this work. Beſides, what remains to be ſaid upon the ores of mercury, antimony, biſmuth, arſenic, and cobalt, is already ſufficiently explained in the different articles of this Dictionary relating to theſe ſubſtances, and to their products. The fuſion in great of ores of iron would indeed particularly deſerve to be treated more extenſively, on account of its importance; but we obſerve, that the general principles of the ſmelting of ores contained in the preſent article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatiſes, which are not wanting on this ſubject, and particularly to the *Art of Forges and Iron-furnaces*, deſcribed moſt exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correſpondent of that Academy; a work which makes part of a general deſcription of the Arts undertaken by that illuſtrious company. (*q*)

(*q*) In this work, which pretends to treat of the principles of arts in general, we ought certainly not to omit ſome deſcription of the methods of procuring and manufacturing a metal, ſo extenſively uſeful, that without it no other art could have been perfected, and even, as ſome writers have obſerved, mankind could not have been civilized.

In the article Iron, the author of the Dictionary has deſcribed the chemical properties of that metal, or its effects when acted upon by fire, acids, and other ſubſtances. The ſubjects of this note and of the article Steel are the proceſſes by which iron is obtained from its ores, and reduced to the ſeveral ſtates of *caſt iron*, *forged iron*, and *ſteel*, and the properties of this metal in theſe ſeveral ſtates, which render it fit for the various uſes to which it is daily applied.

Notwithſtanding the great importance of theſe ſubjects, and the labors of Reaumur, Swedenborgius, and of ſome other authors, we have ſtill a very imperfect knowledge of the cauſes of the differences of the ſeveral kinds of ores, of the methods of ſmelting beſt adapted to theſe differences, of the cauſes of the good and bad qualities of different kinds of iron, and of the means of ſo meliorating this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very induſtriouſly and exactly deſcribed the different proceſſes now uſed in moſt parts of Europe for the ſmelting of ores of iron, for the forging of that metal, and for the converſion of it into ſteel: but we do not find that he or any other author have, by experiments and diſcoveries, contributed much to the illuſtration or to the improvement of this part of metallurgy, unleſs, perhaps, we except thoſe of Mr. Reaumur, concerning the ſoftening of caſt iron by cementation with earthy ſubſtances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fuſibility, in the methods neceſſary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Moſt ores require to be *roaſted* previouſly to their fuſion; ſome more ſlightly, and others with a more violent and longer-continued fire. Thoſe which contain much ſulphur, arſenic, or vitriolic acid, require a long-continued and repeated roaſting, that the volatile matters may be expelled.

Some ores require a very ſlight roaſting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others, which being in a calcined ſtate, and containing no ſulphureous or inflammable matters, would, by a further calcination, be rendered leſs capable of uniting with phlogiſton, and conſequently of being reduced to a metallic ſtate.

Alſo the ores which are attractable by magnets, and which contain iron in a ſtate nearly metalliſed, require little or no roaſting.

The roaſting of ores of iron is performed by kindling piles, conſiſting of ſtrata of fuel and of ore, placed alternately upon one another, (*See* Plate II. *Fig.* 11. *and* 12.), or in furnaces ſimilar to thoſe commonly employed for the calcination of lime-ſtone.

Some authors adviſe the addition of ſome calcareous earth to ſulphureous ores during the roaſting, that the ſulphur may be ab-

ſorbed

DCXXXII. SNOW *of* ANTIMONY. The flowers of regulus of antimony are ſo called. *See* FLOWERS *of* REGULUS *of* ANTIMONY.

ſorbed by this earth when converted into quicklime. But we may obſerve, that the quicklime cannot abſorb the ſulphur or ſulphureous acid, till theſe be firſt extricated from the ore, and does therefore only prevent the diſſipation of theſe volatile matters; and, ſecondly, that the ſulphur thus united with the quicklime forms a hepar of ſulphur, which will unite with and diſſolve the ore during its fuſion, and prevent the precipitation of the metal.

The next operation is the *fuſion* or *ſmelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty feet high, in the bottom of which is a baſon for the reception of the fluid metal. *See a Section and Deſcription of this Furnace in* PLATE II. *Fig.* 20, *and the Explanation of that Figure.* When the furnace is ſufficiently heated, which muſt be done at firſt very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limeſtone, or whatever other flux is employed. While the fuel below is conſumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, ſink gradually down, till they are expoſed to the greateſt heat in the furnace. There the ore and the flux are fuſed, the metallic particles are revived by the phlogiſton of the fuel, are precipitated by means of their weight through the ſcoria formed of the lighter earthy parts of the flux and of the ore, and unite in the baſon at the bottom of the furnace, forming a maſs of fluid metal covered by a glaſſy ſcoria. When a ſufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of ſand; and from thence into ſmaller lateral or connected channels, or other moulds. There it is cooled, becomes ſolid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called *a ſow*, and thoſe formed in the ſmaller channels are called *pigs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of ſand or of clay, and is thus formed into the various utenſils and inſtruments for which caſt iron is a proper material.

The *ſcoria* muſt be, from time to time, allowed to flow out, when a conſiderable quantity of it is formed, through an aperture made in the front of the furnace for that purpoſe. A ſufficient quantity of it muſt, however, be always left to cover the ſurface of the melted iron, elſe the ore which would fall upon it, before the ſeparation of its metallic from its unmetallic parts, would leſſen the fluidity and injure the purity of the melted metal. This ſcoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a ſcoria, not ſufficiently fluid, is always found to contain much metal. If the ſcoria be too thin, the metallic particles of the ore will be precipitated before they are ſufficiently metallized, and ſeparated from the earthy and unmetallic parts. A due degree of fluidity is given to the ſcoria by applying a proper heat, and by adding fluxes ſuited to the ore.

Some ores are fuſible without addition, and others cannot be ſmelted without the addition of ſubſtances capable of facilitating their fuſion.

The *fuſible ores* are thoſe which contain ſulphur, arſenic, or are mixed with ſome fuſible earth.

The ores *difficultly fuſible* are thoſe which contain no mixture of other ſubſtance. Such are moſt of the ores which are attractable by magnets, and which contain iron in a ſtate nearly metallic. As iron itſelf, when purified from all heterogeneous matters, is ſcarcely fuſible without addition, ſo the metal contained in theſe purer kinds of ores cannot be eaſily ſeparated without the addition of ſome fuſible ſubſtance. [illegible] which are mixed with ſome very refractory ſubſtance. Some of theſe refractory ores contain arſenic; but as this ſubſtance facilitates the fuſion of iron, we may preſume that

DCXXXIII. SOAP. The name *ſoap* was formerly employed only to ſignify combinations of alkaline ſalts with oils, that is, compounds in which

that their refractory quality depends upon a mixture of ſome unmetallic earth or other unfuſible ſubſtance.

Perhaps the fuſibility of different ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; ſince we have reaſon to believe that, by a very perfect calcination, ſome metals, at leaſt, may be reduced to the ſtate of an earth almoſt unfuſible, and incapable of that intimate union with phlogiſton in which metalliſation conſiſts (*ſee the article* METALS); and ſince we know, that in every calcination and ſubſequent reduction of a given quantity of any imperfect metal, a ſenſible part of that quantity is always loſt or deſtroyed, however carefully theſe operations may have been performed. If this notion be juſt, the moſt probable means of improvement in the ſmelting of ores of imperfect metals, eſpecially of iron, ſeem to be by diſcovering ſome method of effecting the combination or intimate union of phlogiſton with metallic earths or calxes, more compleatly and certainly than by immediately expoſing them to a melting heat, in which thoſe metallic particles only can be revived, that are already much diſpoſed to metalliſation. That ſome of theſe ores are already too much calcined, appears from the inſtance above-mentioned of the *bog ores*, which are injured by roaſting; and even the great height of the common ſmelting furnaces, although advantageous to many ores that require much roaſting, is ſaid to be injurious to thoſe which are already too much calcined, by expoſing them to a further calcination, during their very gradual deſcent, before they arrive at the hotteſt part of the furnace, where they are fuſed.

Farther, when we conſider how many inſtances occur of combinations which can be effected only by ſlow degrees, we have reaſon to hope, that methods of more effectually combining phlogiſton with metallic earths may be diſcovered, by which a larger proportion of metal may be obtained from the ores, eſpecially the calciform ores of iron, and perhaps of other imperfect metals, than is now obtained by the methods commonly practiſed.

Various *ſubſtances are added to aſſiſt the fuſion of ores* difficultly fuſible. Theſe are; 1. *Ores* of a fuſible quality, or which, being mixed with others of a different quality, become fuſible; accordingly, in the great works for ſmelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fuſion, and alſo to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-ſhort*, and another ore which produces iron brittle when cold, or *cold-ſhort*, are often mixed together; not, as is ſometimes ſuppoſed, that theſe qualities are mutually deſtructive of each other, but that each of them is diminiſhed in the mixed maſs of iron, as much as this maſs is larger than the part of the maſs originally poſſeſſed of that quality. Thus, if from two ſuch ores the maſs of iron obtained conſiſts of equal parts of cold-ſhort and of red-ſhort iron, it will have both theſe qualities, but will be only half as *cold-ſhort* as iron obtained ſolely from one of the ores, and half as *red-ſhort* as iron obtained only from the other ore. 2. *Earths* and *ſtones* are alſo generally added to facilitate the fuſion of iron ores. Theſe are ſuch as are fuſible, or become fuſible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous nature, limeſtone or ſome calcareous earth ſhould be added; and that if the adherent earth be calcareous, an argillaceous earth ſhould be added; becauſe theſe two earths, though ſingly unfuſible, yet, when mixed, mutually promote the fuſion of each other; but as limeſtone is almoſt always added in the ſmelting of iron-ores, and as in ſome of theſe, at leaſt, no argillaceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fuſion, not by uniting with an argillaceous earth, but by uniting with that part of the ore which is moſt perfectly calcined, and leaſt diſpoſed to metalliſation; ſince we know, that by mixing a calciform or roaſted ore of iron with calcareous earth, without any inflammable matter, theſe two ſubſtances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron, by* oils are rendered miſcible with water, by means of an alkali. But ſince chemiſts, by a more exact examination of the nature of bodies, have diſ-

by Mr. Brandt, in the Swediſh Memoirs for the years 1749 *and* 1751.

Some authors pretend, that a principal uſe of the addition of lime-ſtone in the ſmelting of iron-ores is to abſorb the ſulphur, or vitriolic acid, of theſe ores: but, as we have already obſerved, a hepar of ſulphur is formed by that mixture of calcareous earth and ſulphur, which is capable of diſſolving iron in a metallic ſtate; and thus the quantity of metal obtained from an ore not ſufficiently diveſted of its ſulphur, or vitriolic acid, (which, by uniting with the phlogiſton of the fuel, is formed into a ſulphur during the ſmelting) muſt be conſiderably diminiſhed, though rendered purer, by addition of calcareous earth: hence the utility appears of previouſly expelling the ſulphur and vitriolic acid from the ore by a ſufficient roaſting. 3. The *ſcoria* of former ſmeltings is frequently added to aſſiſt the fuſion of the ore; and, when the ſcoria contains much iron, as ſometimes happens in ill conducted operations, it alſo encreaſes the quantity of metal obtained.

The quantity of theſe fuſible matters to be added varies according to the nature of the ore; but ought in general to be ſuch, that the ſcoria ſhall have its requiſite degree of thinneſs, as is mentioned above.

The *fuel* uſed in moſt parts of Europe for the ſmelting of ores of iron is charcoal. Lately, in ſeveral works in England and Scotland, iron-ore has been ſmelted by means of pitcoal, previouſly reduced to cinders or *coaks*, by a kind of calcination ſimilar to the operation for converting wood into charcoal, by which the aqueous and ſulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France, pitcoal not calcined has been tried for this purpoſe, but unſucceſsfully. The uſe of *peat* has alſo been introduced in ſome parts of England.

The quality of the iron depends conſiderably upon the quality and alſo upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intenſity of the heat, muſt be ſuited to the greater or leſs fuſibility of the ore. Sulphureous, and other ores eaſily fuſible, require leſs fuel than ores difficultly fuſible. In general, if the *quantity of fuel be too ſmall*, and the heat not ſufficiently intenſe, all the iron will not be reduced, and much of it will remain in the ſcoria, which will not be ſufficiently thin. This defect of fuel may be known by the blackneſs and compactneſs of the ſcoria, by the qualities of the iron obtained, which in this caſe is hard, white, light, intermixed with ſcoria, ſmooth in its texture, without ſcales or grains, rough and convex in its ſurface, and liable to great loſs of weight by being forged; and, laſtly, it may be known by obſerving the color and appearance of the drops of metal falling down from the ſmelted ore, and of the ſcoria upon the ſurface of the fluid metal, both which are darker-colored than when more fuel is uſed. When the *quantity of fuel is ſufficiently large*, and the heat is intenſe enough, the iron is darker-colored, denſer, more tenacious, contains leſs ſcoria, and is therefore leſs fuſible, and loſes leſs of its weight by being forged. Its ſurface is alſo ſmoother and ſomewhat concave; and its texture is generally granulated. The ſcoria, in this caſe, is of a lighter color and leſs denſe. The drops falling from the ſmelted ore and the liquid ſcoria in the furnace appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intenſe, the iron will appear to have a ſtill darker color, and more conſpicuous grains or plates, and the ſcoria will be lighter, whiter, and more ſpungy. The drops falling from the ſmelted ore, and the fluid ſcoria, will appear to a perſon looking into the furnace through the blaſt-hole to be very white and ſhining hot. The quantity of charcoal neceſſary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation ſkilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumſtances.

The *time, during which the fluid metal ought to be kept in fuſion* before it is allowed to flow out of the covered, that acids, and even other ſaline ſubſtances, may alſo be united with oils, and may render theſe miſcible with water, they have generaliſed the name

the furnace muſt be alſo attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumſtances, we cannot determine. In ſome works the metal is allowed to flow out of the furnace every ſix or eight, and in others only every ten or twelve hours. Some workmen imagine, that a conſiderable time is neceſſary for the concoction of the metal. This we are certain of, that the iron undergoes ſome change by being kept in a fluid ſtate; and that if its fuſion be prolonged much beyond the uſual time, it is rendered leſs fluid, and alſo its cohesion, when it becomes cold, is thereby greatly diminiſhed. The Marquis de Courtivron ſays, that the coheſion may be reſtored to iron in this ſtate, by adding to it ſome vitreſcible earth, which he conſiders as one of the conſtituent parts of iron, and which he thinks is deſtroyed by the fuſion too long continued. That the fuſibility of caſt iron does depend on an admixture of ſome vitreſcible earth, appears probable from the great quantity of ſcoria forced out of iron during its converſion into malleable or forged iron, and from the loſs of fuſibility which it ſuffers nearly in proportion to its loſs of ſcoria. The quantity of iron daily obtained from ſuch a furnace as we have deſcribed, is from two to five tons in twenty-four hours, according to the richneſs and fuſibility of the ore, to the conſtruction of the furnace, to the adjuſtment of the due quantity of flux and of fuel, and to the ſkill employed in conducting the operation.

The *quality of the iron* is judged by obſerving the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large ſparkles; if many brown ſpots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its ſurface is ſpotted; it is known to have a red-ſhort quality. If, in flowing, the iron ſeems covered with a thin glaſſy cruſt, and if, when cold, its texture be whitiſh, it is believed to be cold-ſhort. Mr. Reaumur ſays, that dark-colored caſt iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle caſt iron, ſometimes ductile forged iron is produced. Caſt iron with brilliant plates and points, when forged, becomes ſometimes red ſhort and ſometimes cold-ſhort. Large ſhining plates, large cavities called *eyes*, want of ſufficient denſity, are almoſt certain marks of bad iron; but whether it will be cold or red-ſhort cannot be aſfirmed till it be forged. Whiteneſs of color, brittleneſs, closeneſs of texture, and hardneſs, are given to almoſt any caſt iron by ſudden cooling; and we may obſerve, that in general the whiter the metal is, the harder it is alſo, whether theſe properties proceed from the quality of the iron, or from ſudden cooling; and that, therefore, the darker-colored iron is fitter for being caſt into moulds, becauſe it is capable in ſome meaſure of being filed and poliſhed, eſpecially after it has been expoſed during ſeveral hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it ſofter, and more capable of being filed than before, and alſo conſiderably leſs brittle.

Mr. Reaumur found, that by cementing caſt iron with abſorbent earths in a red-heat, the metal may be rendered ſofter, tougher, and conſequently a fit material for many utenſils formerly made of forged iron. Whether cementation with abſorbent earths gives to caſt iron a greater degree of theſe properties than the annealing commonly practiſed, has not been yet determined.

In Navarre, and in ſome of the ſouthern parts of France, iron-ore is ſmelted in furnaces much ſmaller, and of a very different conſtruction from thoſe above deſcribed. A furnace of this kind conſiſts of a wide-mouthed copper-caldron, the inner ſurface of which is lined with maſonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The ſpace or cavity contained by the maſonry is the furnace in which the ore is ſmelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the cavity name of ſoap, and the beſt chemiſts give it now to all combinations of any ſaline ſubſtances with oils, rendered miſcible with water by means of theſe ſaline

cavity is about eight feet, and its ſmaller diameter is about ſix feet: the ſpace of the furnace is gradually contracted towards the bottom, the greateſt diameter of which does not exceed ſix feet: eighteen inches above the bottom is a cylindrical channel in one of of the longer ſides of the caldron and maſonry, through which the nozzle of the bellows paſſes. This channel, and alſo the bellows-pipe, are ſo inclined, that the wind is directed towards the loweſt point of the oppoſite ſide of the furnace. Another cylindrical channel is in one of the ſhorter ſides of the furnace, at the height of a few inches from the bottom, which is generally kept cloſed, and is opened occaſionally to give paſſage to the ſcoria; and above this is a third channel in the ſame ſide of the furnace, through which an iron inſtrument is occaſionally introduced to ſtir the fluid metal, and to aſſiſt, as is ſaid, the ſeparation of the ſcoria from it. The greateſt height of this channel is at its external aperture on the outſide of the furnace, and its ſmaller height is at its internal aperture; ſo that the inſtrument may be directed towards the bottom of the furnace; but the ſecond channel below it has a contrary inclination, that when an opening is made, the ſcoria may flow out of the furnace into a baſon placed for its reception. When the furnace is heated ſufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previouſly roaſted. They take care to throw the charcoal chiefly on that ſide at which the wind enters, and the ore at the oppoſite ſide. At the end of about four hours a maſs of iron is collected at the bottom of the furnace, which is generally about ſix hundred weight: the bellows are then ſtopt; and when the maſs of iron is become ſolid, the workmen raiſe it from the bottom of the furnace, and place it, while yet hot, under a large hammer, where it is forged. The iron produced in theſe furnaces is of the beſt quality; the quantity is alſo very conſiderable, in proportion to the quantity of ore, and to the quantity of fuel employed. In theſe furnaces no limeſtone or other ſubſtance is uſed to facilitate the fuſion of the ore. We ſhould receive much inſtruction concerning the ſmelting of iron-ore, if we knew upon what part of the proceſs or circumſtance, the excellence of the iron obtained in theſe furnaces depends; whether on the quality of the ore; on the diſuſe of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminiſhed; on the forging while the iron is yet ſoft and hot, as the Marquis de Courtivron thinks; or on ſome other cauſe, not obſerved.

The iron thus produced by ſmelting ores is very far from being a pure metal; and though its fuſibility renders it very uſeful for the formation of cannon, pots, and a great variety of utenſils, yet it wants the ſtrength, toughneſs, and malleability, which it is capable of receiving by further operations.

Caſt-iron ſeems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cauſe of its fuſibility, brittleneſs, hardneſs, and other properties by which it differs from forged iron. The ſulphur, arſenic, and other impurities of the ores, which are ſometimes contained in caſt iron, are probably only accidental, and may be the cauſes of the red-ſhort quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned ſeems principally to diſtinguiſh caſt iron from forged or malleable iron; for, firſt, by depriving the former of this earthy matter, it is rendered malleable, as in the common proceſs hereafter to be deſcribed; and, ſecondly, by fuſing malleable iron with earthy and vitreſcible matters, it loſes its malleability, and is reſtored to the ſtate and properties of caſt iron.

The earthy vitreous matter contained in caſt iron conſiſts probably of ſome of the ferruginous earth or calx of the ore not ſufficiently metalliſed, and alſo of ſome unmetallic earth. Perhaps it is only a part of the ſcoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more ſeparated, as the heat applied is more intenſe, and as the fuſion is longer continued.

To ſeparate theſe impurities from caſt iron, and to unite the metallic parts more ſubſtances. The vegetable kingdom contains many ſuch ſaline, oily combinations ſoluble in water. All vegetable acids, fluor or concrete; eſſential ſalts; ſac-

cloſely and compactly, and thus to give it the ductility and tenacity which render this metal more uſeful than any other, are the effects produced by the following operations.

The firſt of theſe operations is a fuſion of the iron, by which much of its impurities is ſeparated in form of ſcoria; and by the ſecond operation, a further and more compleat ſeparation of theſe impurities, and alſo a cloſer compaction of the metallic particles, are effected by the application of mechanical force or preſſure, by means of large hammers.

Some differences in the conſtruction of the forge or furnace, in which the *fuſion* or *refining of caſt iron* is performed, in the method of conducting the operation, and in ſome other circumſtances, are obſerved to occur in different places. We ſhall deſcribe, from Suedenborgius, the *German method.*

The fuſion of the caſt-iron, which is to be rendered malleable, is performed upon the hearth of a forge ſimilar to that uſed by blackſmiths: at one ſide of this hearth is formed a cavity or fire place, which is intended to contain the fuel and the iron to be melted: this fireplace is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep: it is bounded on three ſides by three plates of caſt-iron placed upright; and on the fourth ſide, which is the front, or that part neareſt to which the workmen ſtand, by a large forge-hammer, through the eye of which the ſcoria is at certain times allowed to flow. The floor alſo of the fire-place is another caſt-iron plate. The thickneſs of theſe plates is from two to four inches. One of the upright ſide-plates reſts againſt a wall, in an aperture thro' which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of caſe or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube reſts upon the upper edge of the ſide-plate which leans againſt the wall, nearer to the back-part than to the front of the fire-place, and in ſuch an oblique direction, that the wind ſhall be impelled towards the furtheſt part of the floor of the fire-place, or where this floor is interſected by the oppoſite ſide plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be ſhifted till its proper poſition is found. The more nearly its direction approaches to a horizontal plane, the more intenſe is the heat; but a larger quantity of fuel is conſumed than is even proportional to the encreaſe of heat, becauſe the flame is not then ſo well confined. When the iron is eaſily fuſible, great heat is not required: the tuyere may then decline conſiderably from the horizontal plane, and thus fuel may be ſaved. This tuyere, though made of copper, a metal more eaſily fuſible than iron, is preſerved from fuſion by the conſtant paſſage of cold air through it. It muſt be carefully kept open, and cleanſed from the ſcoria, which would be apt to block its cavity, by which not only the heat would be too much diminiſhed for the ſucceſs of the operation, but the tube itſelf would be melted.

To prepare for the fuſion, a quantity of ſcoria of a former operation is thrown into the fire-place, till one-third part of this be full; and the remaining two-thirds of the fire-place are to be filled with ſmaller ſcoria, coal duſt, and ſparks ejected from hot iron. Theſe matters, being fuſible, form a bath for the reception of the iron when melted. Upon this bed of ſcoria, the maſs of caſt-iron to be melted is placed; ſo that one end of it ſhall be within the fire-place, oppoſite to the tuyere, and at the diſtance of about four or five inches from its aperture; and the other end ſhall ſtand without the fire-place, to be puſhed in, as the former is melted. The upper ſide of the maſs of iron ought to be in the ſame horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its courſe, ſtrike upon and paſs along the underſide of the maſs: but if the iron be difficultly fuſible, the tuyere is to be diſpoſed more horizontally, ſo that the wind ſhall ſtrike directly upon the maſs of iron; and that one part of the blaſt ſhall graze along the upper ſurface, and the other part along the under ſurface of the charine juices; the extractive matter of plants, properly ſo called, are ſaponaceous ſubſtances, or acid ſoaps. In many of theſe ſoaps, ſuch as eſſential

iron. The maſs of iron weighs generally from two hundred to four hundred pounds. Sometimes two or three ſmaller maſſes are put one above another, ſo as not to touch. When theſe are of different qualities, the cold-ſhort piece is placed undermoſt, that being more unfuſible than the red-ſhort. The iron being placed, charcoal-powder is thrown on both ſides, and coals are accumulated above, ſo as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at firſt ſlowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted ſcoria to the bottom of the fire-place; during which the workmen frequently turn the iron, ſo that the end oppoſed to the blaſt of wind may be equally expoſed to heat, and uniformly fuſed. While the coals are conſumed, more are thrown on, ſo that the whole may be kept quite covered. During the operation, a workman frequently ſounds the bottom and corners of the fire place, by means of a bar or poker, raiſes up any maſs of metal which he finds adhering to theſe, and expoſes them to the greateſt heat, that they may be more perfectly fuſed.

When all the iron is fuſed, no more coals are to be added; but the melted maſs is to remain half uncovered for ſome time; during which the iron boils and bubbles, and its ſurface ſwells and riſes higher and higher. When the iron has riſen as high as the upper edge of the fire place, the coals upon its ſurface muſt be removed; and by thus expoſing it to cold air, its ebullition and ſwelling ſubſide. In this ſtate, or coction, the iron is kept during half an hour or more, by adding occaſionally pieces of good coal, which maintain a ſufficient heat, without covering entirely the ſurface of the maſs. During this coction, the workmen allow the orifice of the tuyere to be half ſtopped up by the ſcoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued ſufficiently long, they clear the paſſage of the tuyere, and the maſs is ſoon cooled by the cold air. At the ſame time alſo, they open a paſſage in the eye of the hammer placed in the front of the fire place, through which ſome of the ſcoria is allowed to flow out. When the iron has become ſolid, the bellows are ſtopt, the coals are removed, and the maſs is left during an hour; and then the workmen raiſe it from the fire-place, turn it upſide down, and proceed to the ſecond coction or fuſion of the iron.

For this ſecond operation, the maſs is to be ſo placed, that one part of it ſhall reſt upon the tuyere, and the other upon the ſcoria remaining in the fire-place. This ſcoria is to be diſpoſed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to paſs all along the under ſide of the maſs of iron. About the ſides of the maſs, charcoal powder and burnt aſhes are thrown; but towards the tuyere, dry and entire pieces of coals are placed, to maintain the fire. When theſe are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it paſs equally along the under ſurface of the iron, quite to the further extremity, and that it do not eſcape at the ſides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fuſion, pieces of iron are apt to be ſeparated from the maſs, and to fall down unfuſed to the bottom and corners of the fire-place. Theſe are carefully to be ſearched for, and expoſed to the greateſt heat till they are melted. When the whole maſs is thus brought into perfect fuſion, the coals are removed, and the wind blowing on its ſurface, whirls and diſſipates the ſmall remaining pieces of ſcoria, and ſparks thrown out from the fluid iron. This jet of fire continues about ſeven or eight minutes, and the whole operation about two hours. In this ſecond fuſion the ſcoria is to be thrice removed, by opening a paſſage through the eye of the hammer. The firſt time of removing the ſcoria is about twenty minutes from the kindling of the fire; the ſecond time is about forty minutes after the firſt; and the third time is near the end of the operation.

The maſs is then removed from the hearth,

and

ſalts and vegetable acids, the ſaline part predominates over the oily part, and they have therefore been conſidered rather as ſalts, than as ſoaps. But the oil

and put upon the ground of the forge, where it is cleanſed from ſcoria, and beat into a more uniform ſhape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This maſs is to be divided into five, ſix, or more pieces, by means of a wedge; and theſe are to be heated and forged till they are reduced to the form of the bars, commonly ſold.

In ſome forges, the iron is fuſed only once, and in others it ſuffers three fuſions, by which it is ſaid to be rendered very pure. Where only one fuſion is practiſed, it is called the *French method*. In this, no greater quantity of iron is fuſed at once than is ſufficient to make one bar. The fireplace is of conſiderably leſs dimenſions, and eſpecially is leſs deep than in the German method above deſcribed. The fire is alſo more intenſe, and the proportion of fuel conſumed to the iron is greater. The iron, when melted, is not kept in a ſtate of ebullition as is above deſcribed; but this ebullition is prevented by ſtirring the fluid maſs with an iron bar, till it is coagulated, and becomes ſolid.

By theſe operations, fuſion and forging, the iron loſes about $\frac{3}{11}$ parts of its former weight, ſometimes more and ſometimes leſs, according to the quality of the caſt iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more cloſely compacted, its texture is changed, and it is rendered more denſe, ſoft, malleable, tough, and difficultly fuſible.

The degrees however of theſe qualities vary much in different kinds of iron. Thus ſome iron is tough and malleable, both when it is hot and when it is cold. This is the beſt and moſt uſeful iron. It may be known generally by the equable ſurface of the forged bar, which is free from tranſverſe fiſſures or cracks in the edges, and by a clear, white, ſmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-ſhort* iron, and is generally known by a texture conſiſting of large, ſhining plates, without any fibres. It is leſs liable to ruſt than other iron. A third kind of iron, called *red-ſhort*, is brittle when hot, and malleable when cold. On the ſurface and edges of the bars of this kind of iron, tranſverſe cracks or fiſſures may be ſeen; and its internal color is dull and dark. It is very liable to ruſt. Laſtly, ſome iron is brittle both when hot and when cold.

Moſt authors, agree that the red-ſhort quality of iron proceeds from ſome ſulphur or vitriolic acid being contained it, becauſe ſulphur is known to produce this effect when added to iron; and becauſe the iron obtained from pyritous and other ſulphurated ores has generally this quality.

The cauſe of the cold-ſhort quality of iron is not ſo well aſcertained. Some imagine that it proceeds from a mixture of arſenic or of antimony. But this opinion ſeems to be improbable, when we conſider that theſe metallic ſubſtances may in a great meaſure be diſſipated by roaſting, whereas the ores which yield a cold-ſhort iron are injured by much roaſting; that no arſenic or antimony are obſervable in moſt, if in any, of theſe ores; and laſtly, that theſe ſemi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be deſtroyed by cementation with phlogiſton, and by forging. And laſtly, others aſcribe the cold-ſhort quality of iron to a defect of phlogiſton, or, as Suedenborgius ſays, of ſulphur. To aſcertain the cauſes of the bad qualities of iron, and to diſcover practicable remedies, are ſtill deſiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be obſerved, which run all along its whole length: and ſcarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the ſmelting; and alſo from that practice of mixing two or more pigs of caſt iron of different qualities in the finery of theſe: by which means, the red-ſhort and the cold-ſhort qualities of the different kinds are not, as we have already remarked, mutually counteracted or deſtroyed by each other, but each of theſe qualities is diminiſhed in the mixed maſs of iron, as much as contained in all theſe compounds is rendered perfectly miſcible with water by means of the ſaline matter, and it is conſequently in a ſtate truly ſaponaceous.

this maſs is larger than the part of the maſs originally poſſeſſed of that quality: That is, if equal parts of red-ſhort and of cold-ſhort iron be mixed together; the mixed maſs will be only half as red-ſhort as the former part, and half as cold-ſhort as the latter. For theſe different kinds of iron ſeem as if they were only capable of being interwoven and diffuſed through each other, but not of being intimately united or combined.

Of the SMELTING *of* TIN-ORES.

The tin-ores commonly ſmelted are thoſe which conſiſt of calx of tin combined with calx of arſenic and ſometimes with calx of iron. Theſe are either pure, as the tin-grains, or intermixed with ſpars, ſtones, pyrites, ores of copper, iron, or of other metals.

The impure ores muſt be *cleanſed* as much as is poſſible from all heterogeneous matters. This cleanſing is more neceſſary in ores of tin than of any other metal, becauſe in the ſmelting of tin-ores a leſs intenſe heat muſt be given than is ſufficient for the ſcorification of earthy matters, leſt the tin be calcined. Tin-ores previouſly bruiſed may be cleanſed by waſhing, for which operation their great weight and hardneſs render them well adapted. If they be intermixed with very hard ſtones or ferruginous ores, a ſlight roaſting will render theſe impure matters more friable, and conſequently fitter to be ſeparated from the tin-ores. Sometimes theſe operations, the roaſting, contuſion, and lotion, muſt be repeated. By roaſting, the ferruginous particles are ſo far revived, that they may be ſeparated by magnets.

The ore, thus cleanſed from adhering heterogeneous matters, is to be *roaſted* in an oven or reverberatory furnace with a fire rather intenſe than long continued, during which it muſt be frequently ſtirred to prevents its fuſion. By this operation, the arſenic is expelled, and in ſome works is collected in chambers built purpoſely above the calcining furnace.

Laſtly, the ore cleanſed and roaſted is to be *fuſed*, and reduced to a metallic ſtate. In this fuſion, attention muſt be given to the following particulars. 1. No more heat is to be applied than is ſufficient for the reduction of the ore, becauſe this metal is fuſible with very little heat, and is very eaſily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is uſed in this than in moſt other fuſions. 3. The ſcoria muſt be frequently removed, leſt ſome of the tin ſhould be involved in it, and the melted metal muſt be covered with charcoal powder to prevent the calcination of its ſurface. 4. No flux or other ſubſtance, excepting the ſcoria of former ſmeltings which contains ſome tin, are to be added, to facilitate the fuſion.

SMELTING *of* ORES *of* LEAD.

Ores of lead are either *pure*, that is, containing no mixture of other metal; or they are *mixed* with ſilver, copper, or pyrites. The methods of treating ores of lead containing ſilver and copper, are deſcribed in the articles SMELTING *of* ORES *of* SILVER and *of* COPPER; and in the former of theſe articles, an inſtance is given of the method of ſmelting the ore of Rammelſberg, which contains all theſe three metals.

Pure ores of lead, and thoſe which contain ſo ſmall a quantity only of ſilver as not to compenſate for the expence of extracting the nobler metal, may be ſmelted in furnaces, and, by operations ſimilar to thoſe uſed at Rammelſberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead is obtained by a kind of *eliquation*, during the roaſting of the ore. For this purpoſe, the ore is thrown upon ſeveral ſtrata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a baſon placed for its reception. The ore which is thus roaſted is beat into ſmaller pieces, and expoſed to a ſecond operation ſimilar to the former, by which more

We may alſo combine acids directly with oils, and thus may form artificially acid ſoaps. But theſe operations are difficult and exhibit many ſingular appearances,

metal is eliquated; and the remaining ore is afterwards ground, waſhed, and ſmelted in the ordinary method.

The lead of Willach is the pureſt of any known. Schlutter aſcribes its great purity to the method uſed in extracting it, by which the moſt fuſible, and conſequently the pureſt part of the contained lead is ſeparated from any leſs fuſible metal which happens to be mixed with it, and which remains in the roaſted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are ſmelted either *upon a hearth*, or *in a reverberatory furnace*, called *a cupol*.

In the firſt of theſe methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fuſion is very quickly effected; and the lead flows from the hearth as faſt as it is ſeparated from the ore.

3. In the ſecond method practiſed in England, pit-coal is uſed as fuel. The furnace is repreſented by *Fig.* 14. *and* 15. PLATE II. The ore is melted by means of the flame paſſing over its ſurface; its ſulphur is burnt and diſſipated, while the metal is ſeparated from the ſcoria, and collected at the bottom of the furnace. When the ore is well cleanſed and pure, no addition is requiſite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fuſible ſpar found in the mines is generally added to render the ſcoria more fluid, and thereby to aſſiſt the precipitation of the metal. When the fuſion has been continued about eight hours, a paſſage in the ſide of the furnace is opened, through which the liquid lead flows into an iron ciſtern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid maſs a quantity of ſlaked quicklime, which renders the ſcoria ſo thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the ſmelting of lead-ores in England, but thinks that it is intended to facilitate the fuſion of the ore, whereas it really has a contrary effect, and is never added till near the end of the operation, when the ſcoria is to be raked from the ſurface of the metal.

Of the SMELTING *of* ORES *of* SEMIMETALS.

ANTIMONY is obtained by a kind of eliquation from the minerals containing it, as is deſcribed in the article ANTIMONY: and the regulus of antimony is procured from antimony, by the proceſſes deſcribed in the ſame *article*, and in the article REGULUS *of* ANTIMONY.

ARSENIC, SAFFRE, and BISMUTH are obtained generally from one ore, namely, that called *cobalt*. The arſenic of the ore is ſeparated by roaſting, and adheres to the internal ſurface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the ſides of which are ſeveral doors, by means of which the arſenic, when the operation is finiſhed, may be ſwept out and collected. Theſe chimneys are generally bent, in a zig-zag direction, that they may better retard and ſtop the arſenical flowers. Theſe flowers are of various colors, white, grey, red, yellow, according to the quantity of ſulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated ſublimations; while ſome alkaline or other ſubſtances are added to detain the ſulphur, and to aſſiſt the purification.

In the ſame roaſting of the ore by which the arſenic is expelled, the biſmuth, or at leaſt the greateſt part of this ſemimetal which is contained in the ore, being very fuſible, and having no diſpoſition to unite with the regulus of cobalt, which remains in the ore, is ſeparated by eliquation.

The remaining part of the roaſted ore conſiſts chiefly of calx of regulus of cobalt, which not being volatile, as the arſenic is, nor ſo eaſily fuſible as biſmuth is, has been neither volatilized nor melted. It contains alſo ſome biſmuth, and a ſmall quantity of arſenic, together with any ſilver or other fixed metal which happened to be contained in the ore. This roaſted ore being reduced to a fine powder, and mixed with three or four times its weight of fine ſand, is the according to the ſtate and nature of the acids and oils combined. Vitriolic and nitrous acids, eſpecially when well concentrated, act ſo powerfully upon all drying, ſweet, or eſſential oils, that they produce conſiderable alterations. Nitrous acid inflames them, or, when not ſufficiently concentrated to produce this inflammation, it reduces them, as the vitriolic acid alſo does, into thick, reſinous, and bituminous compounds. The action of theſe acids appears leſs ſtrong upon the fat oils, which do not dry, and are capable of forming with them true acid ſoaps. But all theſe matters have been but ſuperficially examined, and may be conſidered, by perſons deſirous of extending chemical knowledge, as a new ſubject.

DCXXXIV. SOAP (COMMON). Common ſoap is a combination of oil of olives with fixed alkali rendered cauſtic by quicklime. Soap may be made by ſeveral methods, which however all depend upon the

powder called *ſaffre* or *zaffre*. *See* SAFFRE. Or the roaſted ore is ſometimes fuſed with about thrice its quantity of pure ſand and as much pure potaſh, by which a blue glaſs, called *ſmalt*, is produced (*ſee* SMALT), and a metallic maſs, called *ſpeiſs*, is collected at the bottom of the veſſel in which the matters are fuſed. The metallic maſs or ſpeiſs is compoſed of very different ſubſtances, according to the contents of the ore and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, biſmuth, arſenic, ſulphur, copper, and ſilver.

Biſmuth is ſeldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a ſufficient quantity of theſe was found, by the ſame method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and inveloped in much earthy or other matter, from which it cannot be ſeparated merely by waſhing, is diſtilled either by aſcent, or by deſcent. When it is mineraliſed by ſulphur, that is, when it is contained in cinnabar, ſome intermediate ſubſtance, as quicklime, or iron, muſt be added in the diſtillation, to diſengage it from the ſulphur. *See* CINNABAR. The rich ore of Almaden in Spain is a cinnabar, with which a calcareous ſtone happens to be ſo blended, that no addition is required to diſengage the mercury from the ſulphur. The diſtillation is there performed in a furnace conſiſting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, reſting upon a grate, through the bars of which the air enters, maintains the fire, and paſſes into a chimney, placed at one ſide of the fire-place immediately above the door through which fuel is to be introduced. The roof of this fire place, which is vaulted and pierced with ſeveral holes, is alſo the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be diſtilled is introduced, through a door in one of the ſides of the furnace. In the oppoſite wall of this cavity are eight openings, all at the ſame height. To each of theſe openings is adapted a file of aludels connected and luted together, extending ſixty feet in length. Theſe aludels, which are earthen veſſels open at each end, and wider in the middle than at either extremity, (*ſee* ALUDEL *and* PLATE I.) are ſupported upon an inclined terras; and the aludel of each file, that is moſt diſtant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled ſufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatiliſed, and its vapor paſſes into the aludels, where much of it is condenſed, and the reſt is diſcharged into the brick-chamber, in which it circulates till it alſo is condenſed. If any air or ſmoke paſſes through the aludels along with the vapor of the mercury, they eſcape through the two chimneys of the chamber. Three days after the operation, when the apparatus is ſufficiently cooled, the aludels are unluted, and the doors of the chamber are opened, and the mercury is collected.

ſame principle. The ſoap which is uſed in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spaniſh ſoda are boiled together, during a ſhort time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phiol which is capable of containing an ounce of water, ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoons becomes thick and white. The combination is gradually compleated, and in ſeven or eight days a very white and firm ſoap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and ſoda is made, but is leſs concentrated than that above deſcribed, and only ſo much that it can ſuſtain a freſh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the reſt of the lixivium is to be added to it, and the whole is to be digeſted with a very gentle heat, till the ſoap be completely made. A trial is to be made of it to examine whether the juſt proportion of oil and alkali has been obſerved. Good ſoap of this kind ought to be firm and very white when cold, not ſubject to become moiſt by expoſure to air, and entirely miſcible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the ſurface. When the ſoap has not theſe qualities, the combination has not been well made, or the quantity of ſalt or of oil is too great, which faults muſt be corrected.

In ſoft or liquid ſoaps, green or black ſoaps, cheaper oils are employed, as oil of nuts, of hemp, of fiſh, &c. Theſe ſoaps, excepting in conſiſtence, are not eſſentially different from white ſoap.

Any fixed alkalis are much diſpoſed to unite with oils that are not volatile, both vegetable and animal, ſince this union can be made even without heat. The compound reſulting from this union partakes at the ſame time of the properties of oil, and of alkali; but theſe properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into ſoap has not nearly the ſame acrimony as when it is pure; it is even deprived of almoſt all its cauſticity, and its other ſaline alkaline properties are almoſt entirely aboliſhed. The ſame oil contained in ſoap is leſs combuſtible than when pure, from its union with the alkali, which is an uninflammable body. It is miſcible or even ſoluble in water to a certain degree, by means of the alkali. Soap is entirely ſoluble in ſpirit of wine, and ſtill better in aqua vitæ ſharpened by a little alkaline ſalt, according to an obſervation of Mr. Geoffroy.

When oil unites with alkali in the formation of ſoap, it is little altered in the connexion of its principles, for it may be ſeparated from the alkali by decompoſing ſoap with any acid, and may be obtained nearly in its original ſtate. By the accurate inveſtigation that Mr. Geoffroy has made of ſoap, by decompoſing it thus by means of an acid, he found that two ounces of this compound conſiſt of one ounce, three gros and one ſcruple of oil, one gros and a ſcruple of marine alkali deprived of all oil and moiſture, or twice the quantity of this ſalt containing the water of its cryſtallization, and, laſtly, two gros and four grains of water. This latter quantity of water is nevertheleſs variable, according to the condition of the ſoap; for it may be much more or much leſs dry.

Concerning the decompoſition of ſoap by means of acids we muſt obſerve, firſt, that all acids, even the weakeſt vegetable acids, may occaſion this decompoſition, becauſe every one of them has a greater affinity than oil with fixed alkali. Secondly, theſe acids, even when united with any baſis, excepting a fixed alkali, or the inflammable principle, are capable of occaſioning the ſame decompoſition; whence all ammoniacal ſalts, all ſalts with baſis of earth, and all thoſe with metallic baſes, are capable of decompoſing ſoap, in the ſame manner as diſengaged acids are; with this difference, that the oil ſeparated from the fixed alkali, by the acid of theſe ſalts, may unite more or leſs intimately with the ſubſtance which was the baſis of the neutral ſalt employed for the decompoſition.

Soap may alſo be decompoſed by diſtillation, as Lemery has done. When firſt expoſed to fire, it yields a phlegm called by him a ſpirit; which nevertheleſs is neither acid nor alkaline, but ſome water which enters into the compoſition of ſoap. It becomes more and more colored and empyreumatic as the fire is encreaſed, which ſhews that it contains the moſt ſubtle part of the oil. It ſeems even to raiſe along with it, by help of the oil and action of the fire, a ſmall part of the alkali of the ſoap: for, as the ſame chemiſt obſerves, it occaſions a precipitate in a ſolution of corroſive ſublimate. After this phlegm, the oil riſes altered, preciſely as if it had been diſtilled from quicklime, that is, empyreumatic, ſoluble in ſpirit of wine, at firſt ſufficiently ſubtle and afterwards thicker. An alkaline reſiduous coal remains in the retort, conſiſting chiefly of the mineral alkali contained in the ſoap, and which may be diſengaged from the coal by calcination in an open fire, and obtained in its pure ſtate.

As all oils contain an acid more or leſs combined, which may alſo be more or leſs diſengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the ſoap is ſaturated with the acid of the oil, eſpecially after the diſtillation of the ſoap. But this matter has not been ſo well examined, that we can affirm any thing concerning it.

Alkaline ſoaps are very uſeful in many arts and trades, and alſo in chemiſtry and medicine. Their principal utility conſiſts in a deterſive quality that they receive from their alkali, which, although it is in ſome meaſure ſaturated with oil, is yet capable of acting upon oily matters, and of rendering them ſaponaceous and miſcible with water. Hence ſoap is very uſeful to cleanſe any ſubſtances from all fat matters with which they happen to be ſoiled. Soap is therefore daily uſed for the waſhing and whitening of linen, for the cleanſing of woolen-cloths from oil, and for whitening ſilk and freeing it from the reſinous varniſh with which it is naturally covered. Pure alkaline lixiviums being capable of diſſolving oils more effectually than ſoap, might be employed for the ſame purpoſes; but when this activity is not mitigated by oil as it is in ſoap, they are capable of altering and even of deſtroying entirely by their cauſticity moſt ſubſtances, eſpecially animal matters, as ſilk, wool, and others: whereas ſoap cleanſes from oil almoſt as effectually as pure alkali, without danger of altering or deſtroying, which renders it very uſeful.

Soap furniſhes medicine with a very efficacious and valuable remedy. Til lately, that Mrs. Stephen's lithontriptic remedy has been publiſhed, phyſicians attended little to the medicinal qualities of ſoap. They ſoon found that ſoap, which is the principal ingredient of this famous remedy, is alſo the only one which has any real efficacy. And although this remedy has been found to be inſufficient to diſſolve moſt ſtones of the bladder, yet experience and obſervation have ſufficiently evinced that it can prevent the enlargement, or even the formation, of ſtones in perſons diſpoſed to that diſeaſe; that it can, in a word, attenuate, divide, and expel the ſtoney particles generated in the urinary paſſages, and which are the firſt materials of the ſtone. And accordingly ſoap is frequently uſed ſucceſsfully in theſe caſes. When ſoap was once diſcovered to act ſenſibly on the glue or binding ſubſtance of that urinary ſand, gravel, and even of ſome ſtones, it was naturally ſuppoſed to be capable of acting more powerfully on other thickened matters, which are too frequent cauſes of many obſtinate diſeaſes. Theſe conſiderations have induced the beſt practitioners to preſcribe ſoap as a reſolving, aperitive, and deobſtruent remedy; and we are certain that it has been employed as ſuch with great ſucceſs.

From the properties of ſoap we may know that it muſt be a very effectual and convenient anti-acid. It abſorbs acids as powerfully as pure alkalis and abſorbent earths, without having the cauſticity of the former, and without oppreſſing the ſtomach by its weight, like the latter.

Laſtly, we may perceive that ſoap muſt be one of the beſt of all antidotes to ſtop quickly, and with the leaſt inconvenience, the bad effects of acid corroſive poiſons, as aqua fortis, corroſive ſublimate, &c.

DCXXXV. SOAP (STARKEY's). This preparation is a combination of fixed vegetable alkali with eſſential oil of turpentine. It is named from the inventor, a chemiſt, called Starkey, who endeavoring to reſolve the problem of the volatiliſation of ſalt of tartar, combined that alkali with ſeveral ſubſtances; and particularly with oil of turpentine, and remarked that from this latter mixture a ſaponaceous compound was formed, which has been ſuppoſed to poſſeſs many medicinal virtues. It enters into the compoſition of pills, named alſo from Starkey. The belief of its good qualities has induced perſons to continue the preparation of this ſoap, and to endeavor, but without ſucceſs, to improve the proceſs.

Although fixed alkalis are not abſolutely inactive upon eſſential oils, they cannot however unite as eaſily with theſe, as with ſweet oils, which are not volatile. If we attempt to combine any eſſential oil, and particularly oil of turpentine, with liquid fixed alkali, as in the preparation of ordinary ſoap, we ſhall ſoon find that theſe two ſubſtances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his ſoap than time and patience. His method, which is perhaps the beſt of all, conſiſts in putting dry alkali into a matraſs, and pouring upon it eſſential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was compleated In five or ſix months a part of the alkali and oil are thus combined together, and form a ſort of white ſaponaceous compound. This ſoap muſt be ſeparated from the mixture, and more of it will be afterwards formed in the ſame manner.

Shorter methods have been ſearched for the preparation of this ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and, laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Nevertheleſs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed in the *Journal de Medicine*, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Beaumé has alſo publiſhed in the *Gazette de Medicine* a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of the oil, accelerates conſiderably the operation of Starkey's ſoap.

Another artiſt ſays, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this ſoap ready made; which correſponds with Mr. Beaumé's opinion. Laſtly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary ſoap, conſiderably abridges the operation; and this alſo confirms his opinion, which ſeems to be very probable. We do not mean to blame the zeal of theſe chemiſts in making ſo many attempts to find a method of preparing this ſoap quickly, but we confeſs that the importance of the object does not ſeem adequate to their trouble. For, in fact, what does it ſignify whether this ſoap, not uſed in the arts, and but little in medicine, be quickly or ſlowly made? The eſſential point is not that it be quickly, but well done.

And to ſpeak our ſentiments freely, this preparation ſeems to be uncertain and ill-choſen. For, beſides that the true ſoap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the uſual idea of it, is a thing probably impoſſible, we believe that we may affirm, that the ſaponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the ſame ſtate, and by time neceſſarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only theſe ſoaps made by different proceſſes, but alſo the ſame ſoap, a longer or a ſhorter time after it has been made, and we ſhall find conſiderable differences in their color, ſmell, and conſiſtence. We ſhall find that thoſe deliquiate, and are partly reſolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of ſaturating well the fixed alkali; that others acquire by time a pitchy, yellowiſh, ſemi-tranſparent and reſinous appearance, which contain too large a quantity of thick reſiduum of oil of turpentine. Thoſe ſoaps which ſeem to be the beſt made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preſerve longer their white color and the conſiſtence of true ſoap: But they nevertheleſs participate more or leſs of the faults we have mentioned. Laſtly, all theſe ſoaps are liable to contain a conſiderable quantity of a ſort of neutral ſalt, formed by the acid of the oil of turpentine, united with a part of the alkali of the ſoap. This ſalt cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline effloreſcence. Theſe bad qualities and alterations of Starkey's ſoap cannnot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Theſe ſoaps are known to contain a volatile and ſuperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that theſe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this, we ought to conclude, that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, if, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap. *See* OILS (ESSENTIAL).

DCXXXVI. SOAP-ROCK, *or* SOAP-STONE. *See* STEATITES.

DCXXXVII. SODA. (r)

DCXXXVIII. SOLUTION. Solution conſiſts in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the reſult of this union, we hence ſee that ſolution is nothing elſe than the act of combination.

As the integrant parts of one body cannot unite with thoſe of another, while they adhere together; therefore ſolution cannot be made till the aggregation of one of the two bodies at leaſt is broken. And as bodies whoſe aggregation is broken are neceſſarily in a ſtate of fluidity or of vapors, an axiom has been formed, *Corpora non agunt niſi ſint fluida*, or, Bodies do not act unleſs they be fluid.

(r) *Soda* is a name given to the maritime plant *kali*, from the aſhes of which a conſiderable quantity of mineral alkali may be obtained; and alſo to the aſhes themſelves, or to an impure alkaline ſalt extracted from theſe. *See* KALI, *and* ALKALI (MINERAL).

The two bodies which unite in ſolution are uſually diſtinguiſhed by two different names. That body is generally called the *ſolvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taſte or from its ſolidity appears to be altogether paſſive, is ſaid to be *diſſolved.* Thus, for example, when metal or marble is diſſolved in aqua fortis, theſe ſolid bodies are conſidered as being *diſſolved*, and aqua fortis as the *ſolvent.* But theſe expreſſions ought not to be taken literally, for they would give a very falſe idea of what really happens in ſolution. On the contrary, we are certain that any two bodies, which unite together in ſolution, reciprocally exerciſe their action one upon another, and that the union which reſults from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this reſpect, that body, whoſe ſpecific gravity is greateſt, acts moſt ſtrongly. Mr. Gellert, conſidering the thing in this point of view, affects to repreſent as *ſolvents* the bodies which are generally conſidered as *diſſolved*, and ſays, for inſtance, that *ſand diſſolves alkali.* Provided that we underſtand that the action of the combining bodies is mutual, it ſignifies little that we name the one *ſolvent*, and the other the body *diſſolved*: and even as the word *ſolution*, taken in its moſt proper ſignification, expreſſes the ſeparation of the integrant parts of a body, we ſeem to ſpeak more clearly and accurately when we call that body the *ſolvent*, whoſe integrant parts are already ſeparated before the ſolution, and that the *body diſſolved* whoſe integrant parts are only diſunited during the act of ſolution.

As the ſolution cannot be effected unleſs one of the two bodies at leaſt be fluid, and as ſolid bodies only become fluid by the interpoſition of the parts of ſome other fluid, ſuch as water and watery liquors, or fire, hence ſolution may be made either by the *humid* or by the *dry way.* The ſolutions in which the integrant parts of one of the two bodies, or of both, are diſtributed in an aqueous fluid, as, for inſtance, thoſe of acids, are *ſolutions by the humid way*; and thoſe ſolutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in allays of metals with each other, are *ſolutions in the dry way.*

The ſolution of bodies is not perfect, unleſs each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be tranſparent, we ought to have, after the mutual ſolution, a tranſparent compound, as happens in the ſolutions of calcareous ſtones and acids, and of thoſe of earths by alkalis. As therefore the ſolution of ſoap in water is always a little opake and milky, it ought not to be conſidered as complete. The ſame may be ſaid of glaſſes that are not perfectly tranſparent. Their want of tranſparency always proceeds from the parts of the ſand or flint not having been ſufficiently diſſolved by the ſalt, or from their containing ſome refractory matters, ſuch as certain metallic calxes, particularly calx of tin, which reſiſt the action of ſalts.

As the ſolution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the ſolution, theſe parts are found to adhere together: hence alſo heavy bodies may be ſuſpended in the thinneſt and lighteſt liquids, when they are truly diſſolved by each other. For inſtance, corroſive ſublimate, which is very heavy, may be ſuſpended by ſpirit of wine, which keeps it diſſolved, altho' this liquor be very light. *See* COMPOSITION *and* COMBINATION.

DCXXXIX. SOOT. Soot is a collection of ſubſtances formed by the matter of the flame of inflammable bodies, but which have eſcaped combuſtion, from not having ſufficient contact with the air. This matter, which fixes itſelf to the internal ſurface of chimneys, is always of a black color, more or leſs browniſh. This color it receives from an oil that is burnt, and half reduced to the ſtate of coal.

As all inflammable bodies undergo a total decompoſition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of thoſe which are volatile, are raiſed in vapors, ſome part of which burns with flame, is totally diſſipated and deſtroyed, and another part is ſublimed and adheres to the firſt cold bodies which it meets.

Soot is, as we have now obſerved, the portion of flame which is reduced to black ſmoke, and which has not been inflamed from want of ſufficient contact with air. For if the vapors exhaling from an inflammable body ſtrongly heated were ſo rarefied that each of their parts ſhould be altogether ſurrounded by air, they would all burn with flame, and then we ſhould have no ſmoke or ſoot, or at leaſt this ſoot would not be black, and would contain nothing inflammable. For which reaſon, the greater quantity of air is admitted amongſt bodies which burn with flame, the leſs ſmoke and ſoot we have; and alſo, the ſoot proceeding even from bodies of the ſame kind muſt be very different according to the manner in which they are burnt. In general, we can ſay nothing that will be conſtantly applicable to the nature and principles of ſoot, as its differences ariſe not only from the cauſes abovementioned, but alſo from the nature of the inflammable ſubſtances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, muſt furniſh a ſoot different from that of animal matters; and the ſoot of a pure oil muſt be different from that of a plant containing all its principles. But theſe differences have not yet been obſerved, becauſe chemiſts have not attended to this ſubject.

We know only that the ordinary ſoot of chimneys has an acrid, bitter, empyreumatic, and diſagreeable taſte; that water can extract from it a duſky-colored matter, which ſhews that it contains ſaline, oily, ſaponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are ſet on fire.

If this ſoot be diſtilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid alſo may poſſibly be obtainable from certain ſoots;

and generally towards the end of the diſtillation, when the heat is ſtrong, a little ſal ammoniac is ſublimed.

As every ſoot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables ſuffer, by combuſtion in an open fire, changes ſimilar to thoſe occaſioned by putrefaction. Beſides, the quantity of fixed coal which remains after the diſtillation of ſoot, and which furniſhes a fixed alkali, together with much earth, by incineration, ſhows that a very conſiderable quantity of the fixed principles of inflammable bodies is carried off, and even raiſed to a great height, by means of their combuſtion with flame: but, as we have ſaid, ſoots are very different; and the matter is but little known, and requires further reſearches.

DCXL. SORREL. (s)

DCXLI. SPAR. Naturaliſts and chemiſts have given this name to certain cryſtallized ſtones, more or leſs tranſparent, which generally do not ſtrike fire with ſteel, and which are found plentifully within the earth, but more eſpecially in mines of metals.

Under this general name many ſtones are comprehended; becauſe they have the general properties we have mentioned, and becauſe they reſemble each other by the form of their cryſtallization, in which we always perceive ſhining plates, like mirrors; but ſome of theſe ſtones are very different from others.

Some ſpars are entirely ſoluble with efferveſcence in acids, forming ſelenites with vitriolic acid, deliqueſcent ſalts with nitrous and marine acids, and convertible into quicklime by calcination. Theſe ſtones are juſtly called *calcareous ſpars.*

Others, although entirely ſimilar to theſe in appearance, do not effervеſce with acids, are calcinable as gypſum and ſelenites are, and are, in fact, true ſelenites compoſed of vitriolic acid and calcareous earths. Theſe ſpars are eſſentially different from the former, and are *gypſeous* or *ſelenitic ſpars.*

Other ſpars are neither calcareous nor ſelenitic, do not loſe their tranſparency in the fire, and ſeem to be of the nature of *talc.*

Laſtly, a kind of ſtone, cryſtallized in mirror-like plates like a true ſpar, is almoſt opake, is indiſſoluble by acids, and is ſo much harder than all other ſpars as to be capable of ſtriking fire with ſteel. This ſtone is fuſible without addition, by the action of a violent fire, into a ſemi-tranſparent white matter. This ſeems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fuſible ſpars.* They alſo mention another ſpar which is compact, breaks like glaſs, and melts without addition. From the deſcriptions given by moſt authors we cannot eaſily diſcover what they mean by fuſible ſpar, and by *quartz-ſpar.* Theſe matters have not yet been ſufficiently examined.

From the properties of all the ſubſtances called ſpars we may conjecture, that they are ſtones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of ſome metallic earths, or even by a metalliſation begun in their own earth, ſome properties common to all, or, at leaſt, to the greateſt number.

(s) SORREL. The leaves of this plant contain an acid ſalt which may be obtained from the expreſſed juice by cryſtalliſation. From twenty pounds of freſh ſorrel-leaves Neuman expreſſed ſix pounds of juice, from which two ounces, two drams and one ſcruple of cryſtalliſed ſalt, together with two ounces and ſix drams of an impure ſaline maſs, we e obtained. *See* SALT (ESSENTIAL) *of* SORREL.

Theſe properties are, 1. A certain form of ſhining laminæ in their cryſtalliſation, which appears even in thoſe, the figure of whoſe cryſtals ſeems leaſt diſpoſed to receive this form, as in thoſe which are ſtriated; for ſparry laminæ are diſtinguiſhable at the extremities of the ſtriæ, or bundles of ſtriæ, of which theſe ſpars are compoſed.

2. A greater ſpecific gravity than of all other ſtones. Some ſpars, eſpecially thoſe called *heavy ſpars*, are ſo very heavy, that they come near in this reſpect to metals.

3. A greater fuſibility than of other ſtones; for, beſides thoſe ſpars which are fuſible without addition, the mixture of ſpars facilitates the fuſion of moſt other earths and ſtones, and they are accordingly uſed as fluxes in the ſmelting of moſt metallic ores. Probably for this reaſon theſe ſtones have been called *fluors* by many mineralogiſts and metallurgiſts.

Laſtly, many ſpars are found colored by metallic principles, and imitate the colors of the ſeveral precious ſtones, although they are leſs beautiful and vivid.

We ſhall not enter into a more particular detail concerning ſpars, becauſe what is further known about them rather belongs to natural hiſtory than to chemiſtry; beſides that our knowledge of ſpars is very indiſtinct. (t)

(t) SPARS. This name is given to many ſtones of different properties and appearances, which do not poſſeſs conſtantly any one common character or mark by which they may be certainly diſtinguiſhed from other ſtones. In general, we may obſerve, that they are moſt frequently found in mines, and that they generally conſiſt of ſmooth and ſhining plates or laminæ; that ſome are tranſparent, and others opake; that ſome are colorleſs, and others are colored; that they are cryſtallized in various determinate figures, or poſſeſs no determinate ſhape; and, laſtly, that they differ ſo much in hardneſs, denſity, degree of fuſibility, and in their moſt eſſential chemical properties, that they cannot be conſidered as forming a diſtinct claſs of foſſil ſubſtances. We need not wonder, therefore, that authors, eſpecially thoſe who have not been much accuſtomed to the examination of foſſil bodies, ſhould have given very confuſed and [illegible] deſcriptions of ſpars. Many of them have not been ſufficiently examined; but thoſe of which we have acquired ſome knowledge, we ſhall endeavor to diſtinguiſh into their ſeveral different kinds, and [illegible] than is done in [illegible]. The ſeveral ſtones to which the name of ſpar has been given are, the calcareous, the gypſeous, the fuſible ſpars, and felt ſpar.

1. *Calcareous ſpars* are ſoft, heavy ſtones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called *rhomboidal*. Some ſpars, called *dog's tooth-ſpar*, have a pyramidal figure; but when theſe are broken, their fragments ſhow that they alſo conſiſt of rhomboidal particles.

Some rhomboidal ſpars are tranſparent, others are opake; ſome are colorleſs, and others are colored; laſtly, ſome of them have a ſingular property of refracting doubly the rays of light which paſs through them, and thereby of repreſenting any object, as, for inſtance, the letters of a book, ſeen through it, double. This ſpar has been called *Iſland cryſtal*, or *refracting ſpar*. Its figure is that of an oblique parallelopiped, contained within ſix parallelogram ſides and eight ſolid angles. Each of the obtuſe angles of the parallelograms is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. Theſe are the dimenſions given by Sir Iſaac Newton of the angles of the ſides of the refracting ſpar; and I have found them to correſpond exactly with thoſe which I have ſeen.

Calcareous ſpars may be diſtinguiſhed from others by effervesſcing with acids.

2. *Gypſeous or ſelenitic ſpars.* Theſe are gypſeous

DCXLII. SPELTER. Zinc is ſometimes ſo called. *See* ZINC.

DCXLIII. SPERMA-CETI. (u)

DCXLIV. SPIRIT. The name of ſpirit is given in general to al liquors obtained from ſubſtances by diſtillation. Spirits are of three principa kinds, namely, *inflammable ſpirits*, *acid ſpirits*, and *alkaline ſpirits*.

The claſs of inflammable ſpirits includes the moſt volatile and thinneſt par of eſſential oils; the principle of ſmell, or the *ſpiritus rector* of plants; anc *ardent ſpirits*, or the ſpirit obtained from wine, beer, and all liquors whicl have undergone the *ſpirituous fermentation*.

In the ſecond claſs are all acids obtained by diſtillation of minerals, vegetables, and of animals. Such are, 1. the acids of ſulphur, vitriol, alum, al which are the ſame acid, namely, the vitriolic, and the acids of nitre and o common ſalt. They are called *ſpirit of ſulphur*, *ſpirit of vitriol*, *ſpirit of nitre* &c. without ſpecifying that they are acids. 2. The acids of *vinegar*, and o all liquors which have undergone the *acetous fermentation*, and the acids obtainec in the diſtillation of vegetables, and of certain animals, as flies, ants, &c Theſe ſpirits are commonly called *acid ſpirits*, as the *acid ſpirit of guiacum*, th *acid ſpirits of ants*, &c. becauſe the ſubſtances which furniſh them yield alſc ſpirits that are not acid.

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gypſeous earth, diſtinctly cryſtallized. The form of the cryſtals is rhomboidal. They are alſo called *ſelenites* and *glacies Mariæ*. Sometimes theſe ſpars aſſume other forms. They are very heavy. *See* SELENITES, *and* GLACIES MARIÆ.

3. *Fuſible ſpars*, called alſo *fluors*. Under this name many ſtones are comprehended of different ſhapes, appearances, and perhaps properties. Their general properties are deſcribed under the article FLUOR. They are moſt frequently found in mines, and are much uſed to facilitate the fuſion of ores. Several fluors acquire a phoſphoric property by calcination with inflammable matters. Such is the *Bolognian ſtone*; and alſo other white, heavy, friable, fuſible ſpars, as Mr. Margraaf found. This chemiſt diſcovered, by analyſing the Bolognian ſtone, and other fuſible ſpars capable of receiving a phoſphoric quality, that they conſiſt of a gypſeous earth united with a ſmall quantity of clay. He alſo found, that ſeveral fuſible ſpars could not receive the phoſphoric quality of the Bolognian ſtone. What the cauſe of this difference is, and whether they all conſiſt of the ſame conſtituent parts as thoſe analyſed by Mr. Margraaf, has not yet been diſcovered. *See* FLUOR.

4. *Felt-ſpar*, *Spatum ſcintillans*. This ſtone differs from all the foregoing, in being ſo hard as to be capable of ſtriking ignite ſparks from ſteel. For which reaſon it i referred by Cronſtedt to the ſiliceous claſ of earths, and is by him called *rhombic quartz*; becauſe the particles of which it conſiſt ſeem to be parallelopipeds, each of which i contained within ſix rhombic or rhomboida ſides. Its colors are various, white, grey and red.

Several other foſſil ſubſtances conſiſt o large plates, and are therefore ſaid to hav a *ſparry texture*. Such are ſome kinds o talk, of horn-blend, of quartz, of amianthus, and ſome calciform ores of metals.

(u) SPERMA-CETI is a white, flaky, unctuous ſubſtance, obtained from the heads of whales. It is altogether ſoluble in oils; but is not capable of being diſſolved by cauſtic alkalis, and of forming ſoaps, as other oily matters may. By diſtillation it may be entirely raiſed, without leaving any reſiduum. From four ounces of ſperma-ceti three ounces and a half of oil, and a drachm and a half of phlegm, were diſtilled. The oil diſtilled is not black, fetid, and empyreumatic, like that of other animal ſubſtances, but clear, yellowiſh, and of the conſiſtence of butter. Sugar does not render ſperma-ceti perfectly miſcible with water; but this may be better done by means o yolks of eggs. *Neuman.*

Laſtly, in the third claſs are liquid volatile alkalis, obtained from ſal ammoniac, from all vegetable matters which have undergone a compleat putrefaction, and from all animal matters. They are generally called *ſpirits* only, without ſpecifying their alkaline quality. Thus we ſay, *volatile ſpirit of ſal ammoniac, ſpirit of hartſhorn,* &c. As ſome of theſe ſubſtances, particularly ſal ammoniac, contain alſo an acid which may be obtained from them, we ought, when we mention this ſpirit, to ſpecify its acid quality, and to name it, for inſtance, *acid ſpirit of ſal ammoniac.*

DCXLV. SPIRIT (ARDENT). Ardent ſpirit, called alſo *ſpirit of wine*, becauſe it can be only obtained from ſubſtances which have undergone the vinous fermentation, is a very light, very volatile, very fluid liquor, perfectly white and limpid, and of a ſtrong, penetrating, agreeable taſte and ſmell.

This ſpirit may be eaſily inflamed, without being previouſly heated. Its flame is light, white in the center, blue at its edges, and not very luminous. It is not accompanied with any ſmoke or ſoot. It burns without noiſe, and without any ſuffocating or other vapors.

Spirit of wine perfectly pure, for of that I ſpeak, burns alſo entirely, with concurrence of free air, without leaving the leaſt veſtige of coal, or of any ſaline, earthy, or other reſiduum.

Although ſpirit of wine be altogether inflammable, it is nevertheleſs miſcible with water without any intermediate ſubſtance, and in all proportions, which is a ſpecific character of this liquor; for it is the only ſubſtance of the kind known which is poſſeſſed of theſe properties.

If ſpirit of wine be expoſed to heat in cloſe veſſels, it does not inflame, but is eaſily reduced into vapors which paſs in diſtillation. Theſe vapors, when collected, are entirely the ſame ſpirit of wine as before diſtillation, without having received any alteration or decompoſition, however frequently the operation may have been repeated.

Juncker ſays, that if ſpirit of wine be burnt in a tubulated retort, to which a large glaſs receiver has been adapted, it will be changed into a very ſubtle vapor, which condenſes in the receiver, and forms a liquor ſimilar to pure water.

Boerhaave affirms, that when the vapor of burning ſpirit of wine is collected by an apparatus of proper veſſels, it is nothing but very pure water.

The following are the principal properties of ſpirit of wine relatively to other ſubſtances.

It ſeems to have no ſenſible action upon earths, or upon metallic matters, nor even upon many neutral ſalts; but with acids, alkalis, and many oily ſubſtances it exhibits remarkable phenomena.

Spirit of wine unites with all acids; and by this union the acidity of theſe is diminiſhed. Accordingly, the acids thus combined with ſpirit of wine are called *dulcified acids*. *See* WATER *of* RABEL; SPIRIT *of* NITRE, *and* SPIRIT *of* SALT (DULCIFIED).

But when it is mixed in certain proportions with concentrated acids, and diſtilled, at leaſt with moſt of them, it then receives from them, and produces upon them the following alterations.

Firſt of all, ſome of it paſſes over dephlegmated as much as it can be without being eſſentially altered; afterwards it loſes part of the water eſſential to it; conſequently the nature of the remaining part is changed, and it is converted into a liquor, the properties of which ſhew, that it is as much approximated to the nature of oil as it is removed from that of ſpirit of wine. This liquor, which is very fluid and very volatile, is called *ether*, which is, according to what we have ſaid, a ſubſtance exactly intermediate betwixt ardent ſpirit and oil. *See* ETHER.

After this, the ſpirit of wine, or its mixture with acids, acquires all the characters of oil, or rather becomes a genuine oil.

Acids, on their ſide, receive from ſpirit of wine, eſpecially after the formation of ether, all the alterations which they uſually receive from oils with which they have been treated and diſtilled. *See* ETHER.

Very ſtrong and dephlegmated alkalis act ſingularly upon ſpirit of wine, and are even capable of decompoſing it, when aſſiſted by a certain degree of heat. They deprive it, firſt, of all its ſuperabundant water, then of the water it contains as a principle, and, laſtly, they reduce it to the condition of a true oil, without making it paſs, as acids do, through the intermediate ſtate of ether. *See* TINCTURE *of* SALT *of* TARTAR.

Spirit of wine is commonly conſidered as the ſolvent of oils and of oily matters; but properly it is the ſolvent only of one kind of oils. Theſe are the eſſential oils and their concretions, ſuch as balſams and reſins; all which ſpirit of wine can diſſolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain ſubſtances which ſeem to partake more of the nature of true reſins, as copal and bitumens. *See* OILS *and* RESINS.

When ſpirit of wine keeps an oily matter diſſolved, it may be ſeparated by diſtillation, if the oily matter be not volatile, or by diluting the ſolution with a large quantity of water. This water, with which the ſpirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil diſſolved. Hence the oily matter ſeparates at firſt in very ſmall globules, which are diſperſed through the liquor, and give it the white appearance of an emulſion; and theſe globules afterwards collect, forming more conſiderable maſſes, by which the liquor is rendered very clear.

Theſe properties of ſpirit of wine are advantageouſly applied to extract the eſſential oils and reſins of vegetable matters.

Accordingly, by digeſting in ſpirit of wine aromatic plants, for inſtance, thyme, lavender, roſemary, &c. a ſpirituous liquor is obtained, impregnated with the principle of the ſmell, and with the eſſential oil of theſe plants. Theſe ſpirituous aromatic waters, made by infuſion, are of very great uſe in medicine. They are generally colored by a part of the reſinous matter of the vegetables, which the ſpirit of wine alſo diſſolves, or by the ſubſtances of different colors which reſide in the reſinous ſubſtances. They have hence been called *tinctures*. *See* TINCTURES.

By diſtillation is obtained from ſpirituous tinctures a ſpirit of wine, much impregnated with the principle of ſmell, and with the thinneſt and moſt volatile part of the eſſential oils, but free from all extractive or coloring matter; becauſe theſe latter are not ſufficiently volatile to riſe with ſpirit of wine. This

ſpiri

ſpirit of wine is called by the general name *aromatic ſpirituous diſtilled water*, or only by the name of *water*, added to the name of the plant employed: hence the names of *lavender-water*, *roſemary-water*, &c. Waters are alſo made of ſeveral plants, and are diſtinguiſhed by particular names, as *vulnerary-water*, *imperial-water*, &c. All theſe waters are intended for medicine and for the toilette. We may find the details of theſe preparations in books on pharmacy, and particularly in *Mr. Baumé's Elements of Pharmacy*.

When a tincture has been diſtilled, we may find at the bottom of the veſſel the reſinous and extractive part which the ſpirit of wine had diſſolved. Theſe ſubſtances have undergone ſcarcely any alteration, becauſe they have been expoſed only to a very mild heat. Theſe are extracts of plants made by ſpirit of wine. *See* EXTRACT.

If, inſtead of ſubjecting to diſtillation the ſpirituous tinctures of vegetables, they be diluted with a large quantity of water, the reſinous part may be very well obtained pure and ſeparate from the extractive part. This latter part being equally ſoluble in water as in ſpirit, remains diſſolved notwithſtanding the addition of water, while the former part ſeparates, as we have ſaid, and forms a reſinous maſs.

By this method are obtained the reſins of jalap, of ſcammony, of guiacum, and of many other vegetable matters; and theſe reſins, not having undergone the action of fire, are not altered, but remain in the ſame ſtate in which they exiſted in the vegetables.

Spirit of wine diſſolves alſo very well certain ſalts, as ſal ammoniac, corroſive ſublimate, ſedative ſalt, and perhaps many others which we do not know of; becauſe this matter has not been much examined: but this ſpirit has little or no action upon other ſalts, as common ſalt, Glauber's ſalt, nitre, concrete volatile alkali, &c. It does not diſſolve matters purely gummy and gelatinous, or, at leaſt, it diſſolves but a ſmall quantity of them; and as all theſe matters are very ſoluble in water, and as water has a ſtronger affinity with ſpirit of wine than it has with theſe matters, hence this ſpirit may be employed to ſeparate theſe matters from water. For this purpoſe we need only to add a good deal of the ſpirit of wine to the water, which keeps them diſſolved: the ſpirit then ſeizes the water, and obliges the gummy, gelatinous, and ſaline parts which it contained in ſolution to ſeparate from it. The reverſe of all this paſſes in the ſeparation of oily and reſinous ſubſtances from ſpirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by ſeizing upon the water which they contain.

The ſame may be ſaid of the coagulum formed by mixing ſpirit of wine with concrete volatile alkali, diſſolved by the ſmalleſt poſſible quantity of water. This coagulum, which is formed ſuddenly upon the mixture of theſe two liquors, and which is known in chemiſtry by the name *Offa Helmontii*, is nothing elſe than a ſudden cryſtallization of volatile alkali, occaſioned by the addition of ſpirit of wine, which ſeizes the water in which that alkali was diſſolved. The ſame may be ſaid of the cryſtallization of all ſalts, which may be inſtantaneouſly effected by the means of ſpirit of wine. *See* CRYSTALLIZATION.

From what has been ſaid concerning the diſſolving power of ſpirit of wine, we may judge of its great utility in chemiſtry in extractions and ſeparations. It is particularly very uſeful in the analyſis of vegetables and animals by menſtruums.

ſtruums. By reflecting attentively on the properties of this ſolvent, many analyſes and ſeparations which tend to the progreſs and perfection of chemiſtry may be improved.

We ſhall finiſh this article by ſome reflexions on the nature of ſpirit of wine.

Stahl and moſt chemiſts believe, that ſpirit of wine is compoſed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in ſpirit of wine than phlogiſton united with the aqueous principle by means of an acid.

Laſtly, Mr. Cartheuſer poſitively advances, that ſpirit of wine is compoſed of pure phlogiſton, not in an oily ſtate, but immediately united with the watery principle alone.

This diverſity of opinion amongſt the ableſt chemiſts proves, that the true principles of ſpirit of wine are not yet perfectly known. This proceeds from the difficulty of decompoſing it without an intermediate ſubſtance, and alſo from ſeveral phenomena, ſome of which ſeem to ſhew that it is not a true oil that enters as a principle into the compoſition of ſpirit of wine, but phlogiſton alone; while others ſeem to indicate the preſence of a true oil exiſting in the pureſt ſpirit of wine.

If we mix the beſt rectified ſpirit of wine with water, and if we allow it to evaporate ſlowly in open air, we ſhall find upon the ſurface of the water a certain quantity of oil; and we have ſeen above, that a true oil may be obtained from ſpirit of wine by treating it with acids.

But again, if we attend to the eſſential and fundamental properties of ſpirit of wine, to its perfect miſcibility with water, to its flame, which is not accompanied with any ſoot or ſmoke, to the impoſſibility of reducing it without addition to the ſtate of coal; laſtly, to this property, that when it is inflamed we obtain nothing from it but a matter which burns, and pure water; all which properties are not ſuitable to an oil properly ſo called, we muſt acknowledge, that not oil, but pure phlogiſton, is the inflammable principle of ſpirit of wine. We have reaſon to believe, that the oil which is ſeparated from ſpirit of wine by water is extraneous to it, and is only contained in ſpirit of wine, becauſe the means employed to purify this ſpirit are inſufficient to deprive it of all oily matter; and alſo, that the oil obtained from mixtures of ſpirit of wine with acids, is evidently an artificial oil, and produced in the operation, as we may ſee at the word Ether.

As ſpirit of wine contains a pure phlogiſton very much unfolded, and almoſt diſengaged, it acts upon the nervous ſyſtem, like all the ſubſtances which contain a very volatile and very attenuated inflammable principle. See Wine and Phlogiston. It is alſo very powerfully antiſeptic; hence it is very ſucceſsfully employed to preſerve from putrefaction matters ſuſceptible of it. It is uſed topically in gangrenes; and alſo for the preſervation of dead animals, or parts of animals.

See for the rectification and purification of ſpirit of wine, Rectification.

DCXLVI. SPIRIT *of* LIBAVIUS. *See* Liquor (Smoking).

DCXLVII. SPIRIT *of* NITRE. Spirit of nitre and nitrous acid are two names for the ſame thing. For its properties, *ſee* ACID (NITROUS). We ſhall here explain the manner of diſtilling it, or of decompoſing nitre in order to obtain it.

Vitriolic acid, and ſeveral matters containing it, are intermediate ſubſtances employed for the ſeparation of nitrous acid from the fixed alkali with which it is united in nitre; becauſe, in general, the former of theſe two acids is ſtronger than the latter. In ſeveral ways nitrous acid may be obtained by diſtillation; which however are fundamentally the ſame, although they vary in ſome circumſtances, according to the nature of the intermediate ſubſtance employed, and the required ſtrength of the nitrous acid.

The moſt frequent method of diſtilling ſpirit of wine, eſpecially in great works, is to employ clay as an intermediate ſubſtance. As this kind of earth contains vitriolic acid, it is very proper for decompoſing nitre.

Two parts of dry and powdered clay are to be well mixed with one part of nitre. This mixture is to be put into an earthen-ware retort, placed in a reverberatory furnace. To this retort a receiver is to be fitted, which is to be well luted, and the diſtillation is to be promoted by a gradual heat, that is very gentle at firſt, and raiſed towards the end ſo much that the retort ſhall be very red-hot.

The diſtillers of aqua fortis uſe very few precautions, and accordingly their ſpirit is generally weak and impure. For, in the firſt place, they employ nitre of the firſt, or at moſt of the ſecond boiling, which contains always much common ſalt. Hence the acid which they obtain is mixed with a conſiderable quantity of ſpirit of common ſalt. It is conſequently a kind of aqua regia.

In the ſecond place they do not dry well their clay, by which means their acid is weak; although they always keep apart the moſt watery part which paſſes firſt; this they call *dephlegmating it.*

Laſtly, the lute which they uſe for joining their veſſels is only earth formed into a paſte with water, a part of which falls into the receiver, eſpecially when they unlute the veſſels, and renders the ſpirit of nitre turbid. But as almoſt all the aqua fortis which they make is for purpoſes in which the ſame accuracy is not required as in chemical operations, this aqua fortis is ſufficiently good for the uſes for which it is employed.

Diſtillers of aqua fortis do not uſe retorts, but ſtone-ware bottles, with ſhort crooked necks. The receivers are veſſels exactly of the ſame form. Two rows of theſe veſſels are diſpoſed oppoſite to each other, in an oblong furnace called a *galley*; and a wood-fire is uſed for the diſtillation. The operation laſts twelve hours.

Very good, very pure, and even very ſtrong ſpirit of nitre may be made by the method of the diſtillers of aqua fortis. For this purpoſe nitre of the third boiling muſt be employed; the veſſels muſt be carefully luted with a fat lute compoſed of dry clay, pounded, ſifted and formed into a paſte, with a ſufficient quantity of boiled linſeed oil; laſtly, the contained matter muſt be dephlegmated more than is uſual, before the luting is applied. The diſtillers attend to all theſe things, when good ſpirit of nitre is required, and a ſufficient price is given. We may obſerve that ſpirit of nitre is never ſo high colored and ſmoking, when diſtilled by means of clay, as when obtained by the other methods, although it may be equally ſtrong.

DCXLVIII. SPIRIT *of* NITRE (SMOKING). Two methods are uſed in chemical laboratories to obtain a very ſtrong and ſmoking ſpirit of nitre. The firſt is by means of martial vitriol, previouſly calcined till it becomes red-hot, that all the water of its cryſtalliſation may be expelled. Alſo, very pure nitre of the third or even fourth boiling muſt be well dried. Theſe two matters are to be pounded and carefully mixed together in equal proportions. They are then to be poured into a good earthen ware retort through a paper funnel, which paſſes into the belly of the retort, that none of the powder may adhere to the neck of it. The retort is placed in a reverberatory furnace, upon the bars of which is fixed an earthen diſh filled with ſand. To the retort a large glaſs balloon, in which is a ſmall hole, is to be fitted and luted with a fat lute. This lute is to be covered with a cloth ſoaked with another lute made of quicklime ſlaked in air, and formed into a thin paſte with whites of eggs. The whole luting apparatus is to be bound with a ſtring. Then the diſtillation is to be commenced with a very ſlow fire. The balloon will ſoon be filled with red vapors which are condenſed there, while another portion of ſpirit of nitre diſtills gradually by drops. This diſtillation is to be continued till the retort is red-hot, and no more vapor is raiſed.

When the veſſels are cooled, they are cautiouſly to be unluted, and the liquor in the balloon is to be quickly poured into a clean and dry glaſs bottle, through a glaſs funnel; which bottle ought to be quickly ſtopped with a glaſs ſtopple. This is the method of diſtilling ſmoking ſpirit of nitre uſed by Mr. Beaumé; and it is a very good one. The ſmall earthen diſh filled with ſand, on which the bottom of the retort reſts, is very uſeful to prevent the too ſudden and too unequal application of heat, which would make it certainly liable to be broken. The fat lute of clay and linſeed oil is not capable of being injured by acids, and ſtops very cloſely. But as it remains always ſoft, it requires to be held by the linen ſoaked in lute of lime and whites of eggs.

The vapors of this ſmoking ſpirit of nitre are very elaſtic, and difficultly condenſible; for which reaſon the diſtillation muſt be ſlowly conducted, and muſt be avoided in hot weather. A brick wall muſt be interpoſed betwixt the furnace and the balloon to prevent this veſſel from being too much heated, the balloon muſt be covered with wet cloths frequently renewed, and even the ſmall hole of the balloon muſt be ſometimes unſtopped to give vent to the too rarefied and too copious vapors; otherwiſe the whole apparatus would burſt with exploſion.

When we perceive that the drops ſucceed each other rapidly, and that by unſtopping the ſmall hole, red vapors dart out the length of a foot or more with a hiſſing noiſe; this is a ſign that the veſſels are ready to burſt. The heat then muſt be leſſened, and the ſmall hole muſt be very frequently unſtopped, till the diſtillation be much moderated.

Laſtly, when we pour the nitrous acid into the bottle, we ought to be very careful not to ſtand in the way of a current of air, becauſe the vapors are very corroſive and noxious. For the ſame reaſon alſo, the mouth of the balloon ought to be ſtopped as ſoon as the liquor is poured out of it; for the fumes continue in it more than twelve hours.

DCXLIX. SPIRIT (GLAUBER's SMOKING) of NITRE. Glauber was the firſt chemiſt who thought of diſtilling nitrous and marine acids by means of pure vitriolic acid. By this method we may obtain a nitrous acid highly concentrated; and the proceſs is more eaſy, quick, and convenient, than the preceding. This diſtillation ought to be made in the following manner.

Very pure nitre is to be put into a ſtone-ware or glaſs retort. Upon this nitre, one-third part of its weight of pure vitriolic acid, rectified, and highly concentrated, is to be poured through a glaſs funnel, the ſtalk of which ought to be long enough to go down into the belly of the retort, to prevent any of the acid from adhering to its neck. The apparatus of veſſels is to be diſpoſed in the ſame manner as in the preceding experiment, and the diſtillation is to be promoted with the ſame precautions; and with this difference only, that this diſtillation is ſooner finiſhed, and requires a leſs heat towards the end.

The ſpirit of nitre, diſtilled in theſe two latter methods, is the ſtrongeſt and moſt ſmoking that can be obtained. This in Glauber's manner is a little leſs red and ſmoking than the other; although it may be as ſtrong, and even more ſo than the other. The former is rendered ſo ſmoking by the phlogiſton of the iron of the martial vitriol. Some chemiſts add ſome filings of iron in the diſtillation in Glauber's manner, to render the ſpirit more ſmoking.

We may obſerve, that ſpirit of nitre obtained by any of theſe methods is never abſolutely pure. It is indeed free from a mixture of marine acid, when nitre perfectly purified has been employed; but we cannot prevent, eſpecially in the diſtillation in Glauber's manner, ſome part of the vitriolic acid from riſing with it. It muſt therefore be purified from this acid, when the operations or experiments require a perfectly pure nitrous acid. This purification is eaſily effected by adding ſome pure nitre to the ſacid, and diſtilling a ſecond time; by which means the ſmall portion of vitriolic acid mixed with the ſpirit of nitre is made to unite with the baſis of the nitre, and is rendered ſo fixed that it cannot riſe in diſtillation. We may eaſily perceive, that for this rectification of the nitrous acid much leſs heat is required than for the former diſtillations.

All the reſiduums of theſe diſtillations contain a vitriolated tartar, called *ſal de duobus.*

The reſiduum of the diſtillation of ſpirit of nitre by clay contains a vitriolated tartar mixed with a large quantity of earth, and therefore not eaſily to be extracted. The clay is baked, hardened, and generally very red, becauſe the clays employed for this purpoſe are ferruginous. This caput mortuum forms a very good cement uſed for pavements. It is uſed alſo, for ſake of its color, to make compartments, and to vary the colors of ſandy parterres. It is called the *cement of* [illegible].

The reſiduum of the diſtillation by vitriol contains vitriolated tartar, mixed with a pretty large quantity of the martial earth of this vitriol. Vitriolated tartar may be very eaſily obtained from it by lotion with water, which is afterwards to be filtrated, evaporated, and cryſtalliſed. A very red martial earth remains, which is called *colcothar*, or *ſweet earth of vitriol*, after it has been ſufficiently waſhed.

We may remark upon this ſubject, that as the nitrous acid is diſengaged from its baſis by the acid of vitriol, it ought naturally to be applied to the martial earth of this vitriol. But as the nitrous acid adheres but weakly to iron, eſpecially when this metal is calcined and deprived of its phlogiſton, as it is in this operation, the heat that is employed is more than ſufficient to diſengage it, and to make it paſs entirely in diſtillation.

Laſtly, the reſiduum of the diſtillation of ſpirit of nitre in Glauber's manner, when no iron is mixed with it, forms a very white and very pure vitriolated tartar, which may be diſſolved, filtrated, evaporated, and cryſtalliſed.

All theſe reſiduums generally contain alſo a little nitre, which not having been ſufficiently in contact with vitriolic acid, has eſcaped its action, and is not decompoſed.

DCL. SPIRIT (DULCIFIED) *of* NITRE. Dulcified ſpirit of nitre is a mixture of one part of nitrous acid with two parts of rectified ſpirit of wine, digeſted together. (*u*)

As nitrous acid acts powerfully on ſpirit of wine, it is rendered conſiderably milder by this mixture. It is uſed only medicinally, and is conſidered as aperitive, and powerfully diuretic. It is added by drops to potions and juleps, till it has given an agreeable acidity.

DCLI. SPIRITUS RECTOR. The *ſpiritus rector* is a very attenuated, very ſubtle principle, in which the ſmell of all odoriferous bodies peculiarly reſides.

To obtain the ſpiritus rector from odoriferous ſubſtances, theſe matters are to be diſtilled in the cucurbit or body of an alembic placed in a water-bath, with a very gentle heat, that is, from thirty to thirty five degrees of Mr. Reaumur's thermometer, till we perceive that what riſes in diſtillation has little or no ſmell.

The principle of ſmell in bodies is in general too ſubtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly it riſes by means of the water contained in ſubſtances diſtilled in order to procure it, and is diſperſed and overwhelmed in water. If the odoriferous matters from which the ſpiritus rector is required to be procured, were abſolutely dry, and contained no other volatile principles, a little water or ſpirit of wine ought neceſſarily to be added, to furniſh a kind of baſis to this ſpirit, which would otherwiſe be diſſipated and evaporated, ſo that it could not be collected.

This principle of the ſmell of bodies is miſcible with water, with ſpirit of wine, and with oils. It ſeems however to be of different natures, according to the ſubſtances which furniſh it. Its properties ſhew that it is in general compoſed of an inflammable principle, and of a ſaline ſubſtance, both extremely attenuated. But the ſpiritus rector of ſome ſubſtances appears to be more of a ſaline, and that of others more of an oily nature.

All matters, the ſmell of which is quick, pungent, and which do not affect the brain and nervous ſyſtem, as the acrid, cruciform plants, and ſubſtances which undergo the acid fermentation, contain a ſpiritus rector probably more ſaline than oily.

Thoſe on the contrary whoſe ſmell is ſweet, nauſeous, or ſtrong, without acrimony or pungency, and which affect the head, by curing or occaſioning hyſterical or convulſive accidents; ſuch are ambergriſe, muſk, caſtor, burnt

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(*u*) The London and Edinburg Diſpenſatories direct that the mixture ſhould be diſtilled. This operation ought to be performed with a very ſlow, and gradually raiſed fire, that exploſions may be prevented.

coffee, opium, narcotic plants, camphor, all aromatic plants, and laſtly, the ſubſtances which undergo the ſpirituous fermentation; have, according to all appearance, a ſpiritus rector, which partakes of the nature of oil. For beſides that the effects produced by theſe ſubſtances are ſimilar to thoſe of the vapor of charcoal, the ſpiritus rector of ſome of them is really inflammable; as, for inſtance, that of fraxinella, the exhalations from which form an atmoſphere that may be inflamed with a lighted taper.

The ſpiritus rector of all aromatic plants ſeems particularly to be aſſociated with their eſſential oils; at leaſt, all theſe oils contain a good deal of it. To this principle they certainly owe their ſmell, and probably their volatility and thinneſs; for thoſe which from age, or from not having been preſerved in well cloſed veſſels, have loſt their proper ſmell, are at the ſame time much leſs thin and volatile, ſince they are no longer capable of being raiſed by the heat of boiling water; and beſides, the plants from which the ſpiritus rector has been obtained, furniſh little or no eſſential oil. *See* OILS (ESSENTIAL)

The ſpiritus rector, even that of aromatic plants, although it be of an oily nature, is perfectly miſcible with water; which can only proceed from its great tenuity, or from the ſaline principle which enters its compoſition.

DCLII. SPIRIT *of* SALT. The ſpirit of ſalt, or acid of common ſalt, can only be obtained by means of a ſufficiently powerful intermediate ſubſtance, to diſengage it from the native fixed alkali, which is the baſis of common ſalt. Vitriolic acid is the moſt proper and moſt uſeful intermediate ſubſtance for the diſtillation of ſpirit of ſalt. It is employed, either engaged in a baſis with which it has a leſs affinity than with that of common ſalt; or pure, in order to obtain Glauber's ſmoking ſpirit of ſalt.

Ordinary ſpirit of ſalt is diſtilled by the mixture of one part of common ſalt with two parts of dried clay, preciſely in the ſame manner as we have deſcribed for the diſtillation of ſpirit of nitre. *See* SPIRIT *of* NITRE. The ſpirit of ſalt obtained by this method is white and not ſmoking, although it may be conſiderably ſtrong, if the ſalt and clay have been previouſly well dried

We may obſerve, that a ſmoking ſpirit of ſalt cannot be obtained by means of martial vitriol, calcined till it becomes red, as is practiſed for the ſpirit of nitre. I have tried to make this diſtillation; and although a very violent heat was applied, but very little marine acid was procured. The true reaſon of this difference is, that marine acid diſſolves, much more eaſily than nitrous acid, metallic earths deprived of their phlogiſton, and adheres to them much more ſtrongly. Hence, as ſoon as the marine acid is diſengaged from its baſis by the acid of vitriol, it applies itſelf to the martial earth of this vitriol, which retains it with much more ſtrength than it is capable of retaining nitrous acid.

DCLIII. SPIRIT (GLAUBER'S SMOKING) *of* SALT. To have the ſtrongeſt and moſt ſmoking ſpirit of ſalt, we are obliged to employ as an intermediate the pure vitriolic acid, as Glauber has practiſed. But this operation, eſpecially when we would have ſpirit of ſalt highly concentrated, is very difficult and laborious, becauſe the vapors are much more difficultly condenſible than any others. The following is the proceſs ſucceſsfully practiſed by Mr. Beaumé.

Common ſalt is put into a tubulated ſtone-ware or glaſs retort, which is to be placed in a furnace for diſtilling; and to this retort a balloon is to be fitted, exactly in the ſame manner as for the diſtillation of ſmoking ſpirit of nitre. *See* Smoking Spirit *of* Nitre. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glaſs funnel, a quantity of rectified vitriolic acid previouſly diluted with a little water, equal to a third part of the weight of the ſalt, is to be poured at ſeveral different times, and the opening is to be cloſed each time immediately after a part of the acid has been added.

As ſoon as the vitriolic acid is added, we ſee white vapors paſſing from the retort into the receiver. Theſe are the ſmoking ſpirit of ſalt which this acid diſengages, even without fire; for which reaſon theſe firſt vapors ought to be allowed to paſs, before the fire be kindled; which ought not to be done till they are conſiderably diminiſhed, otherwiſe the diſtillation would go on too faſt at firſt, and the veſſels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is neceſſary to continue the diſtillation. Laſtly, the diſtillation is to be conducted to the end with the ſame attentions which we directed for ſmoking ſpirit of nitre; and when it is finiſhed, the ſpirit of ſalt is to be collected in the ſame manner.

Betwixt this proceſs and that by which a ſmoking ſpirit of nitre is obtained in Glauber's manner, two eſſential differences may be perceived. The firſt is, that in this diſtillation the vitriolic acid is not added till the veſſels are arranged and luted; and hence a tubulated retort is neceſſary. The reaſon of this is, that vitriolic acid diſengages the acid of common ſalt without heat, and as ſoon as it touches this ſalt; and that the vapors which paſs out copiouſly from the retort, by keeping the neck conſtantly wet, render the application of the lute impoſſible. When the lute happens during the diſtillation to be deranged, it cannot be again repaired. The ſhorteſt method then is to diſcontinue the operation, and begin again.

The ſecond difference betwixt the diſtillation of ſmoking ſpirit of nitre and ſmoking ſpirit of ſalt by means of vitriolic acid, is, that water is added in the latter diſtillation, and not in the former. The reaſon of this is, that the vapors of concentrated marine acid are ſo much more difficultly condenſible than thoſe of nitrous acid equally concentrated, that if well concentrated vitriolic acid, and decrepitated common ſalt, be employed, almoſt all the marine acid would be diſſipated in vapors which would be loſt, and ſcarcely a ſenſible quantity of liquor would be obtained. *See* Acid (Marine) *for the properties of ſpirit of ſalt, and* Salt (Common).

The reſiduums of the diſtillations of ſpirit of ſalt contain Glauber's ſalt. In that of the diſtillation by means of clay, this ſalt is confounded with much earth, and difficultly obtainable. But the reſiduum of the diſtillation by vitriolic acid is pure Glauber's ſalt. This ſalt appears a white ſaline maſs at the bottom of the retort. It ought to be calcined in a crucible, that any remaining acid may be expelled. It is then to be treated by ſolution, filtration, and cryſtallization.

By this diſtillation, Glauber firſt diſcovered the ſalt which he afterwards examined, and called *ſal mirabile*. This name is ſtill continued; ſo that it is now called *ſal mirabile*, *ſal mirabile Glauberi*, or *Glauber's ſalt*. *See* Salt *of* Glauber.

DCLIV. SPIRIT (DULCIFIED) *of* SALT.

Dulcified ſpirit of ſalt is made by mixing this acid with twice its weight of rectified ſpirit of wine, and digeſting this mixture during a month.

As this acid has much leſs diſpoſition than the vitriolic and nitrous acids to combine with inflammable matters, it cannot be ſo well dulcified as they can by ſpirit of wine.

Authors differ much concerning the methods of dulcification. The proportions are from two to five or ſix parts of ſpirit of wine to one part of ſpirit of ſalt. Some authors do not ſay whether the ſpirit of ſalt ought to be concentrated and ſmoking, or not; others require that a ſmoking ſpirit ſhould be employed Laſtly, ſome direct the diſtillation of the mixture, and others are contented with a ſimple digeſtion. But in whatever manner the operation is performed, the acid remains crude, and not much dulcified: hence dulcified ſpirit of ſalt is not uſed in medicine; for its virtues do not eſſentially differ from thoſe of dulcified ſpirit of nitre, which is infinitely milder.

Marine acid, although very concentrated and very ſmoking, does not produce, when mixed with ſpirit of wine, but a very inconſiderable heat and effervescence, and much inferior to thoſe occaſioned by vitriolic acid, and ſtill more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of ſpirit of wine.

Theſe two ſubſtances are but little altered by being mixed together: for Mr. Pott having combined a dulcified ſpirit of ſalt with an alkali, obtained a *regenerated ſea-ſalt*, which decrepitated upon hot coals, and precipitated lead and ſilver from their ſolutions in nitrous acid into corneous metals. Nevertheleſs, we are certain that a part of the marine acid contracts an union, and even an intimate union, with ſpirit of wine: for Mr. Pott relates, that having diſtilled to dryneſs the thick matter remaining after the moſt fluid and volatile part of the mixture had been ſeparated, he found a black, reſiduous coal, which cannot be obtained by diſtilling any of theſe two matters ſeparately. *See* ETHER (MARINE).

DCLV. SPIRIT *of* SULPHUR. Spirit of ſulphur is nothing elſe than vitriolic acid obtained from ſulphur by burning.

As ſulphur cannot furniſh its acid but by burning, and as it cannot burn but in open veſſels and free air, we can therefore obtain but a ſmall quantity of acid by this method.

Before the acid of ſulphur was known to be the ſame as ordinary vitriolic acid, a ſpirit of ſulphur was prepared with great expence and trouble, upon the ſuppoſition that it had peculiar properties. For this purpoſe, ſulphur was burnt in an open crucible, placed upon a ſtand in an earthen diſh filled with hot water. A large capital or glaſs-bell was ſuſpended above this diſh. The acid of the burning ſulphur meeting the vapor of the hot water, united with this water, and fell down along the ſides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at preſent this operation is only performed to ſhew, that the acid contained in ſulphur is not decompoſed during combuſtion, and that it is only one and the ſame thing with vitriolic acid.

The true method of obtaining much acid of ſulphur is to burn it in cloſe veſſels by means of a ſmall quantity of nitre, as it ſeems to be practiſed in ſome places. *See* CLYSSUS. (*x*)

DCLVI. SPIRIT *of* VENUS. This name is given by chemiſts to the acid of vinegar highly concentrated, obtained by diſtilling verdegriſe, or cryſtals of verdegriſe, or of Venus, which are nothing elſe than combinations of copper with acetous acid.

The operation by which ſpirit of Venus is obtained is very eaſy. Nothing more is required than to put verdegriſe, or cryſtals of verdegriſe, into a retort, one third part of which ought to remain empty, as is uſual: to this retort a receiver is to be adjuſted, and the diſtillation begun with a very gentle fire: the firſt portions of liquor which paſs are to be ſet apart, as they are nothing but phlegm: the diſtillation is to be promoted, by gradually augmenting the fire, till the retort begins to be red-hot, and nothing eſcapes from it.

The acid of vinegar paſſes in this diſtillation partly in white clouds, and partly in drops. This acid is very ſtrong; becauſe in general acids which are combined with any body whatever, are by that means deprived of all their ſuperabundant water. Beſides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be eaſily dephlegmated in the beginning of the diſtillation.

The ſpirit of Venus has a very vivid pungent ſmell, almoſt as ſuffocating as volatile ſulphureous acid. The Count de Lauraguais diſcovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like ſpirit of wine, and leave no reſiduum. This experiment, added to the obſervations made by Beccher and Stahl upon the production of vinegar, ſhew, that ſpirit of wine enters as a conſtituent part into the compoſition of this

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(*x*) The greateſt part of the vitriolic acid now employed is obtained by burning ſulphur. The vapors of burning ſulphur are the volatile, vitriolic, or ſulphureous acid. Theſe are very difficultly condenſible. For which reaſon, very large veſſels and much time are required in this operation. Some artiſts uſe leaden, and others uſe glaſs veſſels. The bottom of each of theſe veſſels is covered with a little water to aſſiſt the condenſation of the vapor. Above the water is placed a ſmall veſſel capable of containing a few pounds of ſulphur, to which a ſmall portion of nitre is added by ſome artiſts, becauſe by this addition, a larger quantity of ſulphur may be burnt without acceſs of freſh air. The veſſels are to be filled with the vapor of hot water, and their ſides wetted with the condenſed ſteam: then the ſulphur is to be kindled by touching it with a red-hot iron: the vapor of the burning ſulphur riſes ſlowly; and when it has riſen as high as the mouth of the great veſſel, this muſt be ſtopt, or very nearly ſtopt, that the vapor may be confined. The ſulphur continues to burn till the air contained within the veſſel and the nitre be no longer capable of maintaining the combuſtion. The vapor remains a conſiderable time before it be entirely condenſed, notwithſtanding that this condenſation is facilitated by the water in the veſſel, and eſpecially by the ſteam of water with which the veſſel was previouſly filled. When all the vapor of the ſulphureous acid is at laſt condenſed, the ſulphur is to be again kindled, and more added if it be neceſſary, and the proceſs repeated as before. When a ſufficient quantity of acid is collected, it is to be taken out of the veſſel; and after it has loſt its *ſulphureous* or volatile quality by expoſure to air, it is concentrated and rectified by diſtillation. *See* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), *and* CONCENTRATION *of* VITRIOLIC ACID.

acid. The Count de Lauraguais alſo obſerved, that ſpirit of Venus well concentrated, eaſily cryſtallizes without addition; and this obſervation has been ſince confirmed by the Marquis de Courtanvaux. *See* FERMENTATION (ACID), *and* VINEGAR.

As the laſt portions of the acid of vinegar adhere pretty ſtrongly to the copper in the verdegriſe, and to the cryſtals of Venus; and as we are obliged to give a ſtrong degree of heat to expell them, they then raiſe along with them a ſmall quantity of this metal, which gives a greeniſh color to the ſpirit of Venus: but it is eaſily freed from theſe cupreous parts by a ſecond diſtillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongſt others, thoſe of forming ether when diſtilled with ſpirit of wine. *See* ETHER (ACETOUS), *and* VINEGAR (RADICAL).

We muſt obſerve, that when verdegriſe is employed for the preparation of ſpirit of Venus, we obtain very little of this ſpirit, and that it is more oily than when it is obtained from cryſtals of verdegriſe, which furniſh nearly one half of their weight of the ſpirit.

After this diſtillation, we find in the retort the copper which had been the baſis of the cryſtals of verdegriſe. This copper is divided into very ſmall parts, which, however, are agglutinated into lumps that are very friable. Its color is blackiſh, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decompoſed towards the end of the diſtillation. Mr. Beaumé obſerves, that this coal is eaſily kindled by the application of fire, and burns, like tinder, upon the ſurface of the copper.

This copper, not having loſt any of its phlogiſton, may be eaſily fuſed into an ingot of red copper. We ought only to add a little black flux, to prevent or repair the calcination which may be made during its fuſion.

DCLVII. SPIRIT *of* WINE. *See* SPIRIT (ARDENT).

DCLVIII. SPIRIT *of* VINEGAR. *See* VINEGAR (DISTILLED).

DCLIX. SPIRIT *of* VITRIOL. This name is given to the firſt portions of phlegmatic vitriolic acid which paſs in the diſtillation of vitriol, or in the concentration of vitriolic acid. The name is given in general to every dilute vitriolic acid.

DCLX. SPIRIT (VOLATILE) *of* SAL AMMONIAC. The volatile ſpirit of ſal ammoniac is the volatile alkali that is the baſis of ſal ammoniac, and that has been diſengaged by means of ſome intermediate ſubſtance, which alſo has taken from it ſome of its oily principle, by means of which it was capable of a ſolid or concrete ſtate; hence this ſpirit is always liquid.

The intermediate ſubſtances which have the property of producing this alteration upon volatile alkali are ſtony and metallic calxes. If two parts of quicklime ſlaked in the air, or of minium, be mixed together with one part of ſal ammoniac, and if this mixture be diſtilled, a fluor volatile alkali will be obtained in form of a very quick and penetrating ſpirit.

Mr. Schloſſer, in his Diſſertation on the Fuſible Salt of Urine, ſays, that the volatile alkali which ſerves as a baſis to the phoſphoric acid in this ſalt is always fluor, whether it be diſengaged by fire alone, or by any intermediate ſubſtance; and that concrete volatile alkali combined with this acid can never afterwards be obtained but in a fluor ſtate; which ſhews, that the phoſphoric acid has the property of taking from volatile alkali the matter by means of which it is cryſtallizable. *See for the properties of volatile ſpirit of ſal ammoniac,* ALKALI (VOLATILE), *and* AMMONIAC (SAL).

DCLXI. STEEL. Steel, conſidered chemically, is nothing elſe than iron reduced by art to a particular ſtate, which occaſions ſome changes in its properties; but theſe properties are eſſentially the ſame as thoſe of iron; that is, iron and ſteel are not two different metals, but the ſame metal in two different ſtates: therefore all the fundamental properties of ſteel are mentioned under the article IRON. We ſhall here only deſcribe the method of making ſteel, explain the theory of that operation, and mention its differences from thoſe of iron.

Stahl, Cramer, and all good chemiſts, juſtly conſider ſteel as an improved iron, which is poſſeſſed of a larger quantity of inflammable principle, ſo neceſſary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We ſhall be convinced of this truth by a deſcription and explanation of the methods of converting iron into ſteel, and by examining the characteriſtic properties of ſteel.

Steel may be made by fuſion or by cementation. The firſt method is uſed to convert iron into ſteel immediately from the ore. All ores of iron are not uſed indifferently for this purpoſe, becauſe ſome of theſe, which are therefore called *ores of ſteel*, are much fitter than others to furniſh good ſteel; and the ſteel extracted from them is called *natural ſteel.*

The other method of making ſteel conſiſts in chuſing the beſt forged iron, or that which is moſt malleable, whether it be hot or cold; and in impregnating this iron with a larger portion of inflammable principle, by cementation alone, without fuſion.

To underſtand well theſe methods of making ſteel, we muſt attend to two eſſential properties of iron. The firſt is, that of all metals it is the moſt difficultly fuſible; and that therefore although in the ſmelting of its ores its fuſion be much aſſiſted by the ſulphureous parts of the ore itſelf, yet, as theſe parts are always expelled as much as is poſſible, iron never enters into ſo thin and perfect a fuſion as the other metals.

The ſecond property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metalliſed without fuſion.

Theſe things being premiſed, it happens, in conſequence of the former property, that, in the firſt fuſion of ores of iron, we obtain only a hard and brittle iron, both from the ſulphureous parts from which this iron is not entirely diſengaged, and from the preſence of a greater or leſs quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metalliſed, from want of immediate contact with the phlogiſton of the fuel.

We may eaſily perceive that theſe earthy parts, unmetallic or not metalliſed, cannot be entirely ſeparated from the perfect iron, becauſe the fuſion is not ſufficiently thin for that purpoſe: but in proportion as the iron is deprived of ſulphur, its fuſion becomes more and more difficult, and we are obliged to have recourſe to another expedient than fuſion to diſengage it from its earthy parts, which in the firſt ſmelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and ſtruck by a very heavy hammer. This percuſſion, that iron ſoftened by heat ſuſtains, preſſes ſtrongly, and ſolders or welds together the metallic parts, which only are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to ſeparate. By this operation theſe unmetallic parts are preſſed between the parts of the iron, and driven by degrees to the ſurface of the metal, from which they are detached in form of duſt and ſcales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The operations by which ſteel is to be extracted from its ores are eſſentially the ſame as theſe employed for iron; but they differ from them in being much more exact; that an iron ſtill purer, more filled with phlogiſton, and better diſengaged from its earthy parts, may be obtained.

To ſucceed in this intention, much ſmaller quantities muſt be fuſed at once than when iron is to be extracted from its ore. Pieces of the firſt fuſion are to be put into crucibles filled and covered with charcoal, and expoſed to a violent heat excited by ſtrong bellows. Theſe pieces are to be well fuſed, and kept in fuſion a longer or ſhorter time, according to the nature of the ore; after which, they are to be forged, as iron is, but always in much ſmaller pieces, and till they are become perfectly ductile both when hot and when cold. Nothing then remains but to temper the ſteel, of which we ſhall preſently ſpeak.

In theſe operations, which are to be ſeveral times repeated, the iron that is changed into ſteel muſt evidently be much better purified, and furniſhed with a much greater quantity of inflammable principle, than in the ſmeltings and fuſions of large quantities of iron. As the maſſes of metal are ſmall in theſe operations for the procuring of ſteel, and as they are ſurrounded with a much larger proportion of charcoal, the fuſion is not only more compleat, by which the ſeparation of the earthy unmetallic parts is much promoted, but alſo a greater number of ferruginous parts are well metalliſed; and as all theſe parts of iron are in more intimate contact with the charcoal, which is capable of ſupplying them with inflammable principle, they receive the whole quantity of this principle, with which they can unite.

The ſame obſervation may be applied to the operation of the forge practiſed upon ſmaller maſſes; for the heterogeneous parts are much more eaſily and copiouſly preſſed out of ſmall maſſes than great.

This exact purification of iron, by which it is converted into ſteel, muſt evidently be attended with conſiderable loſs, or diminution, from the ſeparation of all its heterogeneous parts. This diminution amounts to nearly one half of the weight of the iron. This great loſs does not proceed altogether from the ſeparation of heterogeneous parts; for in all the operations uſed for this ſeparation, ſome part of the metal is always deſtroyed and burnt, although all poſſible precautions are taken to diminiſh this inconvenience, by ſecuring the melted or red-hot metal from the contact of external air as much as is poſſible.

Artificial ſteel is made without fuſion from iron ready forged. The chief point to be attended to in the making of the beſt artificial ſteel, is to chuſe the iron which is moſt perfect and moſt malleable, either when it is hot or cold; which quality always ſhews that the iron is well purified. It is firſt to be forged into plates or bars, rather ſmall than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compoſe this cement vary according to the uſes of different manufactures. They are all good, provided they contain no ſulphur, or vitriolic acid, which might form ſulphur during the operation; becauſe ſulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuſe it, and would, by reducing it to a mineral or pyritous ſtate, give to it qualities very different from thoſe which good ſteel ought to have.

The matters which enter into the compoſition of the cement for ſteel, are the coals of animal or vegetable ſubſtances mixed with aſhes, calcined bones, and other matters of this kind. Mr. Cramer propoſes the two following receipts of cements for ſteel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-aſhes, and mix them very well together: or,

Take two parts of charcoal, moderately pulveriſed; one part of bones, horns, hair or ſkins of animals, burnt in cloſe veſſels to blackneſs, and powdered; half a part of wood aſhes, and mix them well together.

When ſteel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a ſtratum of the cement of about the thickneſs of a finger has been previouſly put and preſſed down The bars ought to be about an inch diſtant from each other, and from the ſides of the crucible. The interſtices and crucible are then to be filled with cement, ſo that the bars ſhall be covered with about the thickneſs of two inches at leaſt. The crucible, previouſly covered with a lid which fits it exactly, and which muſt be carefully luted with clay mixed with ſand, is to be placed in a furnace where an equal fire is to be kept; ſo that the crucible ſhall be red-hot during eight or ten hours: the iron will then be found to be converted into ſteel, which will be ſo much better as the iron employed was of a better quality: it then only requires to be tempered. We may obſerve, that in this operation the iron ſuffers no diminution of weight, and no ſcoria appears upon its ſurface, as Mr. Cramer remarks. By the ſole addition, therefore, of a new quantity of phlogiſton, the iron acquires the quality of ſteel. Thus, if this iron contained ſome parts of martial earth which was not metalliſed, by the cementation they are metalliſed, and the iron or ſteel are thereby improved: but if the iron contained ſome earthy unmetallic parts, they are not ſeparated by this operation, becauſe the metal has not been fuſed; and as the beſt forged iron which is uſually ſold is never ſo well purified from theſe extraneous matters, as that which is converted into ſteel in the great works for procuring ſteel from the ore of iron; hence, in general, artificial ſteel made by cementation is not ſo perfect as that made by fuſion.

We may obſerve that, in the cementation above deſcribed, the iron combines with a part of the phlogiſton of the cement, without fuſion; which effect proceeds from a peculiar property of the earth of iron by which it is capable of combining with the inflammable principle, and of being metalliſed without fuſion, which is, nevertheleſs, neceſſary for the reduction of all other metallic earths.

The ſteel which has received only the above-mentioned preparations differs from iron in its color, which is more dark and brown; in its grain, which is finer and cloſer; in poſſeſſing a greater ductility, flexibility, and ſoftneſs: but the great difference of ſteel from iron, which renders it more valuable for many purpoſes and arts, is the extreme hardneſs it acquires by being tempered.

This operation is very ſimple. It conſiſts in making ſteel red-hot, and then in plunging it ſuddenly in cold water. In an inſtant all the qualities of this ſteel are changed by this tempering; ſo that from being very ductile and ſoft, it becomes ſo hard and ſo ſtiff, that it is no longer capable of being cut by the file, but is itſelf capable of cutting or piercing very hard bodies; that it does not yeld to the hammer, but may be ſooner broken in pieces like a flint, than be extended. It is ſonorous, brittle, very elaſtic, and capable of acquiring the moſt lively and moſt beautiful poliſh, as we ſee in finely wrought toys of ſteel.

The uſe of this metal is very extenſive for numberleſs convenient and neceſſary utenſils of all ſorts, of which without it we ſhould abſolutely be deprived: but what renders its uſe ſtill more general is, that we can diverſify at pleaſure its hardneſs and ductility, by varying the temper. The hotter the ſteel is when tempered, and the colder the water into which it is plunged, the greater hardneſs it acquires; but, at the ſame time, it becomes ſo much more brittle. This very hard temper is neceſſary for certain tools deſigned to cut very hard bodies. On the contrary, the leſs hot the ſteel is when tempered, and the hotter the water is in which it is tempered, the leſs hard it becomes, and alſo the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are leſs liable to have their points broken, or their edges notched, than if they were made of a harder ſteel.

No other general rule can be given for the tempering of ſteel than that we have mentioned. The proper degree of heat is always relative to the uſe to which the tools to be made of this ſteel are to be applied.

Another very convenient property of ſteel is, that after it has been tempered, it may be again untempered and ſoftened to any degree that we think proper. For which purpoſe we have only to heat it more or leſs, and to let it cool ſlowly. By this method we may ſoften the hardeſt-tempered ſteel.

As the temper is a very eſſential point with regard to ſteel, and that the beſt is in general that which gives the greateſt hardneſs, and deſtroys the leaſt of the ductility of the metal, various ſubſtances are uſed, into which ſteel to be tempered is plunged. Such are ſuet, oil, urine, water impregnated with ſoot, with ſal ammoniac, or with other ſalts. Theſe particular methods are the baſes of many ſecrets in different manufactures; their advantages cannot be aſcertained without a very accurate and continued examination. Very intereſting reſearches remain to be made on this ſubject.

Steel is uſually ſold tempered, becauſe, in many manufactures of it, the cuſtom is to temper it as ſoon as it is made, probably that the purchaſers of it may be better able to judge of its quality. When this ſteel is to be uſed, it muſt be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we alſo find amongſt merchants Engliſh ſteel in ſmall bars, which is not tempered, and which is very good.

Well poliſhed plates of ſteel, put on a gentle fire of charcoal, acquire different colors on their ſurface, and paſs ſucceſſively through ſeveral ſhades, as they become hotter, in the following order, white, yellow, orange, purple, violet, and laſtly, blue, which diſappears and leaves a water-color, if the ſteel has been heated too much or too long. Theſe different ſhades mark the degree of heat or of annealing applied to different tools or utenſils. The moſt generally uſed ſhade is the blue, ſuch as that given to ſteel ſprings.

One of the moſt important properties of ſteel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compaſſes cannot be made without needles of ſteel.

From what we have ſaid, we may judge that ſteel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philoſophers, but who were not chemiſts, have advanced, that ſteel was only iron which ſtill retained ſomething of its mineral nature, and that its ſtate was intermediate betwixt that of caſt iron and ſoft forged iron. But this opinion is manifeſtly erroneous. They have been deceived by the hardneſs and brittleneſs of caſt iron, which are nearly as great as in ſteel. But theſe qualities proceed from a remaining part of the mineraliſing ſubſtances, which leave it a pyritous character, very different from that of true ſteel, ſince this can only be hardened by the temper, and ſince in the preparation of it all ſulphureous matter muſt be carefully avoided. The miſtake of theſe authors proceeded from their ignorance of the inflammable principle, the properties of which have been ſo well explained by the illuſtrious Stahl, and from their being led into an error by the old chemiſts, who perpetually confounded phlogiſton, or the pureſt and ſimpleſt inflammable principle of all bodies, with ſulphur, with ſulphureous matters, and with moſt other inflammable compounds.

Steel may be un-made, or reduced to the ſtate of iron, by a management ſimilar to that by which it is made, that is, by cementation. But the cement uſed for this purpoſe muſt be compoſed of ſubſtances entirely free from inflammable matter, and rather capable of abſorbing it, as calcareous earth and quicklime are. By a cementation then with theſe matters continued during eight or ten hours, ſteel is reduced to the ſtate of iron.

Stahl conſiders it as an undecided queſtion, whether ſteel be more fuſible than iron, and ſays, that the workmen cannot decide it from the violence of fire neceſſary to melt either of them. He believed with reaſon, that this queſtion might be decided by melting theſe metals in the focus of a burning ſpeculum. Mr. Macquer ſays, that by this method he found ſteel much more fuſible than iron (y). This greater fuſibility of ſteel can be only attributed to the greater quantity of phlogiſton united with it, as phlogiſton is in general the cauſe of the fuſibility of metals. (z)

(y) Soft forged iron can ſcarcely without addition be brought into perfect fuſion by the heat of our furnaces, till the phlogiſton of the fuel has converted it into ſteel. But ſteel is daily melted and caſt into ingots, called *caſt-ſteel*, by which it is rendered more uniform and ſimilar in all its parts, and thereby fitter for being wrought into the finer kinds of utenſils for which ſteel is employed. This caſt-ſteel, when again reduced

duced to the ſtate of forged iron by cementation with abſorbent earths, is the moſt uniform, equal, perfect iron which can be obtained.

(z) By converſion of iron into ſteel, this metal acquires a cloſer, more compact and finer-grained texture, greater hardneſs, elaſticity, tenacity, ſonorouſneſs, and diſpoſition to receive the magnetic property; and, as is ſaid, a greater gravity, both abſolute and relative. It is alſo rendered leſs liable to ruſt by expoſure to air; and leſs liable to emit ſparkles when heated. The colors or iriſes which ſteel acquires by expoſure to heat, and which are marks by which workmen know when any required heat is given, are not peculiar to ſteel and iron, but may alſo be produced by the ſame means on all other calcinable metals. Theſe colors proceed from a calcination gradually advancing on that part of the metals which is expoſed to air. And as the particles of metals in their different degrees of calcination are probably of different ſizes, ſo they muſt acquire (according to Sir Iſaac Newton's theory, which ſhews that the colors of bodies depend on the ſize of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fuſion, or by cementation with inflammable matters. Anciently ſteel is ſaid to have been made by immerſing forged iron during ſome time in melted crude iron. Forged iron may alſo be changed into ſteel, as Wallerius affirms, by immerſion in melted ſcoria; or by fuſion with black flux, glaſs-gall, or borax; or by ſtrewing ſea-ſalt upon heated iron, and extinguiſhing it in dung.

Various opinions are formed concerning the cauſe of the difference between iron and ſteel. The moſt general opinion attributes this difference to the preſence of a larger quantity of phlogiſton in the latter than in the former. Some authors, attending chiefly to the method of converſion by fuſion, conſider that operation only as a purification of the iron from earthy and heterogeneous particles, and ſteel merely as a more pure and perfect iron. Others, obſerving ſome ſimilitude in the texture of ſteel to certain kinds of caſt iron, and the hardneſs of both theſe, without attending to their eſſential differences, have imagined that the ſtate of ſteel was intermediate betwixt that of caſt and that of forged iron. Laſtly, ſome metallurgiſts maintain that the converſion of iron into ſteel is effected not by abſorption of phlogiſton, but by expulſion of ſulphureous or acid particles. To ſupport this opinion, they obſerve, 1. That ſteel is leſs diſpoſed than iron to ruſt; the cauſe of ruſt being, as they think, an acid contained in iron; 2. That ſteel emits fewer ſparkles under the hammer than iron, which ſparkles are found to be moſt frequent in iron abounding with ſulphur, as in red-ſhort iron; 3. That iron may be converted into ſteel by cementation with alkaline ſalts, capable of attracting the acid and ſulphur; 4. That in the preparation of ſteel by fuſion, the metal is rather expoſed to a diſſipation of its inflammable parts and burnt; than further phlogiſticated; and that this operation is accordingly called by workmen *the burning of ſteel*.

In the preparation of ſteel by fuſion, probably much of the earthy matters contained in the iron may be ſeparated, and any contained acid or ſulphur may be burnt or diſſipated. But the converſion of ſteel into iron by cementation with abſorbent earths, in which operation no acid or ſulphur can be abſorbed by the metal, ſhews that the difference between iron and ſteel does not conſiſt in the preſence of an acid or of ſulphur in the iron, but in the preſence of ſome ſubſtance in the ſteel, which the inflammable cementing ſubſtances can give to it, and of which abſorbent earths can deprive it. This ſubſtance has been, with great probability at leaſt, believed to be phlogiſton; by the addition of which the metal acquires a new texture, together with the hardneſs, elaſticity, and other peculiar properties of ſteel: we doubt not, however, that in the operations for making ſteel, by fuſion or by cementation, any contained acid or ſulphur may be expelled, and thus the metal may be meliorated, and rendered leſs liable to ruſt and to emit ſparkles.

The affinities and medicinal virtues of ſteel are the ſame as thoſe of iron. *See* Iron.

DCLXII. STONES. This name is given in general, both in chemiſtry and in natural hiſtory, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *ſtones.*

As many different kinds of ſtones as of earths may be diſtinguiſhed. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form ſtoney bodies. But as this union of the integrant parts of any earth does not really change the nature of this earth; and as it always has the ſame eſſential properties, eſpecially when conſidered chemically; we refer to the word Earth for all that we have to ſay concerning ſtones. The origin, and the ſenſible qualities by which naturaliſts diſtinguiſh different kinds of ſtones, are treated of in *Mr. Bomare's Dictionary of Natural Hiſtory.*

Several chemical preparations are alſo called ſtones, of which we ſhall here treat.

DCLXIII. STONE (CAUSTIC), *or* Common Caustic. *See* Caustic.

DCLXIV. STONE *of* BOLOGNIA. This ſtone has been much celebrated for the property it has of becoming phoſphoric by calcination. It is a heavy ſelenitic ſpar. All ſpars of that kind, and alſo ſeveral other ſtones, have the ſame property. *See* Phosphoric (Stones), *and* Spars.

DCLXV. STONE (INFERNAL), *or* Lunar Caustic. *See* Caustic (Lunar).

DCLXVI. STONE (PHILOSOPHER's). This name is given by alchemiſts to the preparation, by which metals may be tranſmuted, gold and ſilver made, and all the wonders produced of (what they call) the *great work. See the articles* Metals *and* Metallisation.

DCLXVII. SUBLIMATION. Sublimation is an operation by which volatile and ſolid ſubſtances are collected and obtained.

This operation is founded on the ſame principles as diſtillation, and its rules are the ſame, as it is nothing but a dry diſtillation. Therefore all we have ſaid on the article Distillation is applicable here, eſpecially in thoſe caſes where ſublimation is employed to ſeparate volatile ſubſtances from others which are fixed or leſs volatile.

Sublimation is alſo uſed in other caſes; for inſtance, to combine two volatile matters, as in the operation of the ſublimates of mercury; or to collect ſome volatile ſubſtances; as *ſedative ſalt*, *ſulphur*, and all the preparations called *flowers.*

The apparatus for ſublimation is very ſimple. A matraſs or ſmall alembic is generally ſufficient for the ſublimation of ſmall quantities of matter. But the veſſels and the method of managing the fire vary according to the nature of the matters which ought to be ſublimed, and according to the form which ought to be given to the ſublimate.

The beauty of ſome ſublimates conſiſts in their being compoſed of very fine, light parts; ſuch as almoſt all thoſe called flowers; as *flowers of ſulphur*, and of *benjamin*,

benjamin, *ſedative ſalt*, and others of this kind. When the matters to be ſublimed are at the ſame time volatile, a high cucurbit, to which is adapted a capital, and even ſeveral capitals placed one upon another, are to be employed. The ſublimation is performed in a ſand bath, with only the preciſe degree of heat requiſite to raiſe the ſubſtance which is to be ſublimed; and the capitals are to be guarded as much as is poſſible from heat. The height of the cucurbit and of the capitals is well contrived to accompliſh this intention.

When along with the dry matter which is to be collected in theſe ſublimations a certain quantity of ſome liquor is raiſed, as happens in the ſublimation of ſedative ſalt, and in the rectification of volatile concrete alkalis, which is a kind of ſublimation, a paſſage and a receiver for theſe liquors muſt be provided. This is conveniently done by uſing the ordinary capital of the alembic, furniſhed with a beak, and a receiver.

Some ſublimates are required to be in as ſolid and compact maſſes as their natures allow. Of this number are camphor, ſal ammoniac, and all the ſublimates of mercury. The propereſt veſſels for theſe ſublimations are bottles or matraſſes, which are to be ſunk more or leſs deeply in ſand, according to the volatility and gravity of the matters that are to be ſublimed. In this manner of ſubliming, the ſubſtances having quitted the bottom of the veſſel, adhere to its upper part; and as this part is low and near the fire, they there ſuffer a degree of heat ſufficient to give them a kind of fuſion. The art therefore of conducting theſe ſublimations conſiſts in applying ſuch a degree of heat, or in ſo diſpoſing the ſand, (that is, making it cover more or leſs of the matraſs) that the heat in the upper part of the matraſs ſhall be ſufficient to make the ſublimate adhere to the glaſs, and to give it ſuch a degree of fuſion as is neceſſary to render it compact; but at the ſame time, this heat muſt not be ſo great as to force the ſublimate through the neck of the matraſs, and diſſipate it. Theſe conditions are not eaſily attained, eſpecially in great works.

Many ſubſtances may be reduced into flowers and ſublimed, but which require for this purpoſe a very great heat with the acceſs of free air, and even the contact of coals, and therefore cannot be ſublimed in cloſe veſſels. Such are moſt ſoots or flowers of metals, and even ſome ſaline ſubſtances. When theſe ſublimates are required, the matters from which they are to be ſeparated muſt be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This proceſs is called *ſublimation in the manner of Geber*. The *tutty*, *calamine*, or *pompholix*, which are gathered in the tops of furnaces in which ores are ſmelted, are ſublimates of this kind.

DCLXVIII. SUBLIMATE (CORROSIVE).

This preparation, called alſo *mercury corroſive ſublimate*, is a mercurial ſalt, in which mercury is united with the largeſt quantity of marine acid with which it is capable of combining intimately.

This ſalt is called *ſublimate*, becauſe it can only be well prepared by ſublimation; and it is called *corroſive*, becauſe it is one of the moſt corroſive ſalts or even the moſt corroſive of all ſalts with metallic baſes.

Corroſive ſublimate may be made by ſeveral proceſſes, which, however, are all ſo contrived, that the vapors of mercury and of marine acid ſhall meet in the ſame ſubliming veſſel.

The moſt uſual method conſiſts in mixing well nitrous mercurial ſalt with vitriol of iron and common ſalt, all well dried; and in promoting the ſublimation, as we have ſaid under the article MERCURY.

Another proceſs conſiſts in diſſolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white ſaline maſs remaining after this ſolution, previouſly dried, with an equal weight of dried ſea-ſalt; and in ſubliming this mixture in a matraſs with the heat of a ſand-bath, by encreaſing the fire till nothing more is ſublimed. This proceſs is given by Mr. Boulduc, in the Memoirs of the Academy for the Year 1730. Mr. Spielman obſerves, in his *Chemical Inſtitutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial ſalt quits the mercury to unite with the alkali of common ſalt, to which it has a greater affinity, and with which it forms a Glauber's ſalt, that remains at the bottom of the matraſs after the ſublimation; while the marine acid on one ſide, and the mercury on the other, being both diſengaged, are reduced into vapors by the effect of heat, unite ſtrictly together, and form the corroſive ſublimate, which attaches itſelf to the upper part of the matraſs. This ſublimate conſiſts partly of a white, ſemi-tranſparent, ſaline maſs, and partly of ſhining cryſtals, compoſed of ſmall and pointed plates.

This method of making corroſive ſublimate is well-contrived, and ſeems preferable to the ordinary proceſs; 1. Becauſe the mercury, being previouſly diſſolved by vitriolic acid, is as eaſily and perfectly mixed with common ſalt in this as in the ordinary proceſs. 2. Becauſe the acid of the vitriolic mercurial ſalt diſengages powerfully and plentifully the acid of common ſalt; and that it is neceſſary, as we ſhall ſee, that the mercury ſhould meet all the quantity of marine acid with which it is capable of uniting, to obtain the moſt corroſive ſublimate. 3. The proceſs of Kunckel and Mr. Boulduc is more ſimple than that with vitriol; the operator is leſs expoſed to the acid vapors, the mixture from which the ſublimate is ſeparated is leſs voluminous, and therefore this method is juſtly preferred.

We think we ought to obſerve, upon the ſubject of this proceſs, that almoſt all chemiſts, who have mentioned it ſince Mr. Boulduc, ſay, that it is made from a mixture of turbith mineral with common ſalt. This is an inaccuracy capable of leading readers into a miſtake; for the vitriolic mercurial ſalt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very neceſſary in the operation; whereas turbith mineral contains very little or no vitriolic acid, when it has been well waſhed, according to Mr. Beaumé's experiments; and conſequently if turbith mineral be employed with common ſalt, in the proportions directed by Mr. Boulduc, we ſhould obtain no ſublimate, or but a very ſmall quantity of a ſublimate, which would not be corroſive.

The ſaline ſublimates of mercury may be obtained by ſeveral other proceſſes; for inſtance, the vitriol of the ordinary mixture may be omitted; we might alſo employ crude mercury inſtead of the mercurial nitre, and triturate it a long time with vitriol and ſalt, as Lemery ſays, or ſublime the *white precipitate* alone. But we ſhall ſay no more of theſe methods, becauſe they are all inferior to thoſe we have mentioned, when a very corroſive ſublimate is required; altho' ſome of them, as the ſublimation of white precipitate, be very convenient, and may furniſh a ſublimate which probably is very good, when it is intended to be afterwards converted into *ſweet mercury*, or *mercurial panacea*. But we muſt mention another method of making this ſaline ſublimate of mercury, propoſed alſo by Lemery, becauſe it is founded on a miſtake which ought to be made known.

This method conſiſts in triturating crude mercury with twice its weight of common ſalt; and in ſubliming this mixture, from which, according to Lemery, may be obtained a white ſublimate, leſs corroſive indeed, as he acknowledges, than the ordinary ſublimate, but which, nevertheleſs, is corroſive.

What Lemery ſays upon this ſubject is certainly true; but a modern author infers from thence, that mercury decompoſes common ſalt, that marine alkali has not a ſtronger affinity than mercury with marine acid, and that this experiment contradicts eſtabliſhed affinities. But none of all theſe conſequences is juſtly deducible. We explain this kind of paradox in the following manner.

For this purpoſe we muſt previouſly know, 1. That common ſalt, even when cryſtallized very regularly, is not a pure, homogeneous ſalt; but that it is intimately mixed with another ſalt, compoſed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine ſalt, with calcareous baſis, eſcapes merely by the action of fire, and without any other intermediate ſubſtance than a little moiſture. 3. That when mercury is ſublimed with ordinary common ſalt, that is, common ſalt which has not been purified from the mixture of this ſalt with calcareous baſis, it combines with the acid of this latter ſalt, and not with that of the true common ſalt, and forms a mercurial ſublimate. The proof of this is, that if, as Mr. Beaumé has done, common ſalt be diſſolved in water, and if into this ſolution ſome of the lixivium of ſoda be poured, till no more earth be precipitated, in which operation the ſalt with earthy baſis is evidently decompoſed, and is changed into a ſalt with baſis of fixed alkali; and if the pure ſalt remaining in the liquor be afterwards cryſtallized, and mixed with mercury, and the ſublimation be attempted, not a particle of ſaline ſublimate of mercury will be obtained. This experiment has been verified moſt ſcrupulouſly by Mr. Beaumé. Mercury ſingly cannot decompoſe common ſalt, therefore none of the conſequences inferred from the inaccurate experiment of Lemery are juſtly deducible. We might draw other conſequences not very favourable to the chemiſt alluded to, but we abſtain from them on account of his perſonal merit, and that we may not imitate the harſh and ſatyrical criticiſms which diſhonour his writings.

The ſublimates compoſed of mercury and marine acid, in which the metallic ſubſtance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of a preciſe and determinate proportion of theſe two ſubſtances. Accordingly corroſive ſublimate, when well made, that is, as corroſive as it can be, being ſublimed a ſecond time with new marine acid, does not unite with a larger quantity of acid, nor become more corroſive. But we do not yet ſeem to have determined preciſely the proportion of marine acid, relatively to that of mercury, in the moſt corroſive ſublimate. According to Lemery, ſixteen ounces of mercury produce nineteen ounces of corroſive ſublimate; and, according to Takenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furniſh 360

pounds

pounds of ſublimate; which would ſeem to prove, that the quantity of marine acid is greater in the ſublimate mentioned by Takenius than in that by Lemery. But as more of the mercury may be diſſipated when the quantity operated upon is but ſmall, than when it is large, we can aſcertain nothing from comparing together the reſults of theſe two authors. However, we ſee that the quantity of mercury is much larger than that of the acid, ſince even in the ſublimate of Takenius, the quantity of mercury was more than three times the quantity of acid; which deſerves to be remarked, as we ſhall ſee when we mention the principal properties of corroſive ſublimate.

The ſpecific gravity of this mercurial ſalt has not been hitherto determined, but it is evidently very conſiderable. It is very cryſtallizable, either by the uſual method for cryſtallizing ſalts, or by ſublimation, and the form of its cryſtals is the ſame in both caſes. It is not deliqueſcent, is difficultly wetted by water, and, in this reſpect, is ſimilar to arſenic. It is one of the ſalts which are very little ſoluble in water. According to the experiments of Mr. Spielman, an ounce of diſtilled water can diſſolve only thirty grains of it, with the aſſiſtance of a heat of fifty degrees of Fahrenheit's thermometer, which correſponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can diſſolve only a nineteenth part of its weight of corroſive ſublimate.

All theſe properties of corroſive ſublimate are naturally deducible from the large quantity of mercury which enters its compoſition; it perfectly reſembles in this reſpect all the neutral ſalts, which contain a matter that is not ſaline, intimately joined to the ſaline principle. But this circumſtance is very remarkable, that corroſive ſublimate has at the ſame time very contrary properties, by which it alſo reſembles thoſe neutral ſalts in which the acid is but little connected and imperfectly ſaturated with their baſis. Theſe properties are, 1. Its corroſive quality, which renders it one of the moſt violent and active poiſons; and, 2. Its capacity of receiving a much larger proportion of mercury, which unites intimately with its acid, ſaturates it entirely, and even ſo completely, that this ſalt, from being very corroſive, is rendered, by this new addition of mercury, a ſweet ſublimate, almoſt inſipid, almoſt unſoluble in water, and which has nothing in common with a neutral ſalt but external appearance.

Theſe latter properties of corroſive ſublimate do not allow us to doubt that marine acid, although already united in this ſalt with a large quantity of mercury, and even very intimately, is yet very far from being ſaturated. Accordingly this acid is, at the ſame time, in two ſtates in ſome meaſure contrary. Several of the properties of corroſive ſublimate ſeem to ſhew that its acid is ſaturated as compleatly as the acid of the moſt perfect neutral ſalts; while other properties indicate that it is far from being compleatly ſaturated.

To form a juſt idea of this ſingular ſtate of marine acid in corroſive ſublimate, we muſt firſt of all obſerve, that we ſhould judge very erroneouſly of the ſtate of the acid of a neutral ſalt, if we conſidered the properties of this ſalt as depending only on its acid. We have elſewhere obſerved, and we ſhall prove it further in this article, that bodies which are not ſaline, being united to acids in neutral ſalts, have their peculiar action as well as theſe acids; and that the properties of theſe ſalts are always the reſult of the combined properties of their acids and of their baſes.

In the ſecond place, we ought to recollect the diſtinction we have made under the article SATURATION, into *relative ſaturation*, and *abſolute ſaturation*, which are two things very different; becauſe, in fact, it happens in many combinations, that a principle is in a relative, perfect ſaturation, with regard to another; that is, that it is united with all the quantity of this ſecond principle which it can diſſolve, although it be very far from being in a ſtate of abſolute ſaturation; that is, from having ſo exhauſted all its action upon this ſecond principle, that no more remains to be exerciſed upon any other ſubſtance: For, if this were not ſo, we could not make any decompoſition by an intermediate ſubſtance. Thus in bodies compounded of two principles, ſuch as, for inſtance, neutral ſalts, one of their principles, and not the other, may be relatively ſaturated. Alſo one of the two principles, or both, may be in a perfect, relative ſaturation, although one or both be far from abſolute ſaturation.

Theſe things being premiſed, if we reflect on the properties of corroſive ſublimate, we ſhall eaſily perceive, 1. That the marine acid cannot be united with ſo large a quantity of mercury as it is in this ſalt, without being conſiderably approximated to a ſtate of abſolute ſaturation; hence corroſive ſublimate does not redden blue colors, has no acid taſte, does not attract the moiſture of the air, is very cryſtallizable, and not very ſoluble in water; in a word, that it is nearly in the ſame ſtate as ſeveral neutral ſalts, as vitriolated tartar and others, the acids of which are generally conſidered as being well ſaturated.

Secondly, We ſhall eaſily diſcover alſo, that although the acid of corroſive ſublimate approaches as much to abſolute ſaturation as the above-mentioned properties indicate, it is not nearly in a ſtate of relative ſaturation with regard to the mercury; ſince we know that it is capable of uniting again with a much larger quantity of mercury than is in corroſive ſublimate, as is ſhewn by the transformation of corroſive ſublimate into ſweet mercury; and we ſhall naturally conclude from theſe facts, that marine acid is capable of uniting with ſo large a quantity of mercury, that it cannot be entirely ſaturated with that ſubſtance, without exhauſting almoſt all the action it is capable of, and approaching nearly to the ſtate of abſolute ſaturation. Accordingly we ſee, that the properties of this acid become inſenſible, and are almoſt annihilated in ſweet mercury.

Thirdly, in reaſoning ſtill from principles above-mentioned, and in applying them to corroſive ſublimate, it will evidently appear, that although the acid of this ſalt is not nearly ſaturated with mercury, as we have obſerved, the mercury is nevertheleſs in a ſtate of relative ſaturation, with regard to the acid; ſince, according to Mr. Rouelle's experiment, this ſalt cannot by any means receive a larger quantity of acid. But if, on the other ſide, we attend to the quantity of mercury in corroſive ſublimate, it will appear very probable, that although this mercury be ſaturated with acid as much as it can be, and that in this reſpect it be in a ſtate of perfect relative ſaturation, yet it is very far from having exhauſted upon this acid all the tendency it has to combination in general, and from being in a ſtate of perfect, abſolute ſaturation. In fact, on one ſide, the aggregation of the mercury is broken in corroſive ſublimate, and conſequently all its integrant parts are capable of exerting their general tendency to combination: but, on the other ſide, theſe parts of mercury are united but to a very ſmall quantity of acid, and probably much of their tendency to union remains therefore unſatisfied; and we may reaſonably conjecture, that from this condition, or ſtate of the mercury in corroſive ſublimate, proceeds the cauſticity of that ſaline matter.

This notion will undoubtedly appear very bold to thoſe who are accuſtomed to conſider the cauſticity of ſaline matters as an effect only of the concentration and imperfect ſaturation of their ſaline principles.

But we repeat it, that we ſhould judge very erroneouſly of the properties of any compound body, if we were to attribute them to one of its principles only. On the contrary, all the phenomena of chemiſtry ſhew, that all the conſtituent parts of any compound contribute more or leſs to all the properties of this compound. All the parts of matter are active, by the general tendency which they have to mutual combination. Nothing is purely paſſive in nature; and if certain ſubſtances ſeem to us to be inactive and inert, it is becauſe their parts, having exhauſted all their tendency and activity one upon another, by their union, are in a ſeeming reſt, which we call ſaturation, and do really become inactive with regard to many other bodies: but when by ſome cauſe this union is broken, and its parts become diſengaged, their eſſential activity then appears again in all its force, they reſume all their tendency to combination, they are in a violent ſtate, till they find ſome ſubſtance with which they may unite, and ſatisfy this tendency. This violent ſtate, this *niſus*, are the ſame thing as cauſticity, or rather this latter quality is an effect of the former qualities rendered ſenſible by their exertion upon animated bodies. Accordingly, all matter in nature, however inactive and paſſive it may ſeem, is capable of becoming, by the ſeparation of its primary integrant molecules, an agent or ſolvent, and a very powerful corroſive.

We conceive then, that in corroſive ſublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one ſide, in this violent ſtate, in this tendency to union above-mentioned; and, on the other ſide, that as this tendency to union is only capable of being ſatisfied partly, and imperfectly, by the marine acid, much of it remains unſatisfied, which gives a proportionable degree of cauſticity to theſe molecules; ſo that the mercury itſelf of the corroſive ſublimate is corroſive, and probably much more ſo than even the marine acid.

However ſtrange and ſingular this opinion may appear, we ſhall find, by reflecting on the nature of corroſive ſublimate, that no other cauſe of its cauſticity can be conceived. In fact, we muſt allow that this ſalt is much more cauſtic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be ſwallowed without the leaſt inconvenience; whereas half the quantity of corroſive ſublimate, diluted in the ſame or a much larger quantity of water, would infallibly poiſon. If then we ſuppoſe that the cauſticity of this ſalt is nothing elſe than the cauſticity of the marine acid contained in it, how can we conceive that this acid, which, very far from being diſengaged, and from poſſeſſing all its acidity in corroſive ſublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutraliſed ſo as to form a very cryſtallizable ſalt, not deliqueſcent, and not very ſoluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corroſive than the ſame acid when free and diſengaged? We might as well ſay, that vitriolic acid is more corroſive in vitriolated tartar than when pure. The cauſticity then of corroſive ſublimate muſt be chiefly attributed to the mercury, which is the predominant and leaſt ſaturated part of that ſaline ſubſtance. The mercury in corroſive ſublimate appears to be nearly in a ſimilar ſtate as the earthy principle in fixed alkalis; that is to ſay, its aggregation is deſtroyed, at leaſt in great meaſure, and its quantity is very large in proportion to that of the ſaline principle. Accordingly, corroſive ſublimate, inſtead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the obſervations of Mr Rouelle; and in the ſame manner as alkalis ſeem to owe their cauſticity to the proportion and peculiar ſtate of their earth, ſo alſo does the cauſticity of corroſive ſublimate proceed from the quantity and diſpoſition of its mercury. This cauſticity then is rather of an alkaline than of an acid kind.

An objection might be made here, that if the cauſticity of corroſive ſublimate depended on the mercury, it ought to be encreaſed by encreaſing the proportion of the mercury; whereas we know, that the addition of more mercury has a contrary effect, as we find from the inſtance of ſweet mercury.

The anſwer to this objection is not difficult. Although the cauſticity of corroſive ſublimate depends more on its mercury than on its acid, we cannot doubt that this acid alſo contributes to produce this effect, according to the general rule, that all the principles of bodies conduce more or leſs to their properties: but the acid of ſublimate is indeed nearly in the ſtate of abſolute ſaturation, although it is not quite in that ſtate; and however neutraliſed it may ſeem, it is yet capable of a certain degree of action: but when it is totally ſaturated with mercury, it is then alſo completely in a ſtate of abſolute ſaturation; becauſe this acid is capable of uniting with ſo much mercury, that when it is combined with this metallic ſubſtance, its relative ſaturation and its abſolute ſaturation are almoſt the ſame thing We need not then be ſurprized, that in this reſpect the cauſticity of the ſublimate is conſiderably diminiſhed; but, beſides, when the quantity of mercury much exceeds what ought to be contained in corroſive ſublimate, we may eaſily perceive that the parts of the mercury, being preſſed nearer the parts of the acid, are alſo more and more united together, and approach more nearly to the ſtate of aggregation; in which ſtate mercury cannot have any cauſticity. *See for the properties, chemical and medicinal, of corroſive ſublimate, the articles* ACID (MARINE), *and* MERCURY.

DCLXIX. SUBLIMATE (SWEET). *See* MERCURY (SWEET).

DCLXX. SUBLIMATE (RED). If a ſolution of mercury in nitrous acid be evaporated and dried, and then expoſed to a ſtrong heat in a matraſs, the nitrous acid will be ſeparated from the mercury in great meaſure, and will be diſſipated in red vapors; the ſaline maſs remaining in the matraſs acquires at firſt a yellow color, which afterwards changes to an orange color, and laſtly to a red. This is called *red precipitate*. But by expoſing this red matter to greater heat, it is ſublimed; while its color is preſerved. It is then called *red ſublimate*. This ſublimate is not uſed.

DCLXXI. SUGAR. Sugar is a cryſtallizable eſſential ſalt, of a ſweet agreeable taſte, contained, more or leſs plentifully, in many kinds of vegetables; but in moſt of them in ſo ſmall a quantity, or confounded with ſo much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains [illegible] moſt of this eſſential ſalt is a kind of reed, which grows in hot climates, called ſugar-cane.

The method uſed for the extraction of ſugar from the cane is the ſame as is employed for the extraction of any eſſential ſalt from the juices of plants, with this difference, that as ſugar and liquors containing it are very fermentable, this ſalt is not obtained by a regular cryſtallization, but by a much ſpeedier coagulation.

After having entirely expreſſed the juice from ſugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of aſhes, both to clarify it, and to evaporate it ſo much, that when it cools, moſt of it coagulates or confuſedly cryſtallizes. This coagulated matter is to be ſeparated from the remaining liquor, which is called *melaſſes*. From this liquor, by fermentation and diſtillation, an ardent ſpirit is obtained, called *rum*. The ſolid ſubſtance, or ſugar, is mixed with much mucilaginous extractive matter, which renders it ſoft and red. To purify, or, as it is called, to *refine* it further, it muſt be rediſſolved in pure water, and its heterogeneous parts muſt be ſeparated by boiling with quicklime and lixivium of aſhes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Laſtly, the ſugar, when refined, is put into earthen conical veſſels open at both ends, the ſmaller of which is turned downwards. The ſugar is covered with ſome earth moiſtened with water. This water filtrates through the ſugar, diſſolves the mucilage or ſlime which ſtill adheres to the ſugar, and flows out at the opening in the lower point of the conical veſſel. In this manner is obtained this pleaſant and uſeful ſalt. To whiten and purify it perfectly many clarifications are required; the cauſe of which is chiefly a ſlimy matter, like honey, that adheres to it.

This eſſential ſalt is ſoluble in water, like all other ſalts, and even is one of thoſe ſalts that is ſoluble in the ſmalleſt quantity of water.

It is cryſtallizable; and its cryſtals, when ſlowly and regularly formed, are beautiful and tranſparent, called *ſugar-candy*. This ſalt conſiſts of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of ſweet and not volatile oil, which is in a ſtate perfectly ſaponaceous, that is, entirely ſoluble in water by means of the acid.

Sugar, when diſtilled, yields a phlegm, an oily empyreumatic acid, a ſmall portion of colored empyreumatic oil, and leaves a conſiderable quantity of reſiduous coal.

This ſalt is very ſuſceptible of the ſpiritous fermentation, when it is diluted in a ſufficient quantity of water; and, like all the other ſubſtances capable of that fermentation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables have not been ſufficiently examined, to enable us to determine, whether they be perfectly of a ſaccharine nature. We know, however, that they furniſh by analyſis the ſame principles, and nearly in the ſame proportion; that they all have a ſweet, agreeable, and generally ſaccharine taſte; that every vegetable or animal ſubſtance that is ſaccharine is alſo nutritive and fermentative; and, laſtly, that genuine ſugar may be obtained from moſt of them.

Mr. Margraaf has obtained ſugar from the roots of ſeveral plants, as from carrots, parſnips, white and red beets. Some of theſe roots, as, for example, the white beet, furniſhed a very conſiderable quantity of ſugar. He obtained about half an ounce of ſugar from half a pound of the dried root. This able chemiſt, conſidering that ſugar is ſoluble in ſpirit of wine, and that the mucilaginous parts of plants are not ſoluble in that fluid, eaſily obtained a pure ſugar by digeſting the dried roots in that ſpirit, and by evaporating the liquor. Afterwards, hoping to find a cheaper method, that his diſcovery might be uſeful, he attempted ſucceſsfully to obtain ſugar by the ordinary proceſs very little varied. He could not indeed obtain a very pure ſugar without repeating very frequently the ſolutions, clarifications, and other operations, as may be ſeen in his Memoir, or in the eighth Diſſertation of his *Opuſcules Chemiques*. But at laſt he did ſucceed; and we have reaſon to hope, that by improving the proceſs, much ſugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from ſeveral trees, as the ſycamore, and the birch trees, ſome of which have more of a ſaccharine taſte than ſeveral of the plants from which Mr. Margraaf extracted ſugar.

The chief, and perhaps the only difficulty to be ſurmounted in this extraction of ſugar proceeds from the viſcid matters, which are ſo mixed and blended with the ſaccharine ſubſtance of plants, that they prevent its cryſtallization. The ſaccharine and mucilaginous parts might be ſeparated from each other by means of a menſtruum, which could diſſolve the ſugar and not the ſlimy ſubſtance, or which could diſſolve the latter and not the former. To diſcover ſuch a menſtruum ſeems to be the proper object of inquiry for thoſe who would proſecute this ſubject.

DCLXXII. SUGAR *of* LEAD. *See* Salt *of* Lead.

DCLXXIII. SUGAR *of* MILK. *See* Milk.

DCLXXIV. SULPHUR. No word has been ſo much uſed by chemiſts, and at the ſame time ſo much abuſed, as *ſulphur*. By this the ancient chemiſts denoted all inflammable ſubſtances of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They ſpoke continually of the ſulphurs of metals, of the ſulphurs of plants, of the ſulphurs of animals: oils, ardent ſpirits, reſins, bitumens, were all ſulphurs. In every thing they found a ſulphur. Even now, alchemiſts and others who have only confuſed ideas of chemiſtry, from reading old chemical books, talk inceſſantly and deciſively of ſulphurs.

To Becher, and ſtill more to the illuſtrious Stahl, we owe the ſimple, clear, and preciſe ideas which we now have of the ſeveral kinds of inflammable ſubſtances, formerly confounded under the general name of ſulphur. By the ſagacious diſtinction they have made between the pure and ſimple inflammable principle, and the more compounded bodies which contain it, and owe their inflammability to it, we acquire a knowledge of the true theory of ſulphur and of all inflammable ſubſtances.

Since Stahl has unfolded this ſublime theory, we know that the inflammable principle is identical, always alike, and the ſame in every body; that this principle by its combination with different ſubſtances produces all the inflammable matters which we know. Oils, fats, reſins, bitumens, ardent ſpirits, coals, metals, ſulphur properly ſo called, or common ſulphur, are ſo many compounds, all which have the common property of burning, becauſe they all contain the principle of inflammability, but which differ in other reſpects, becauſe this principle is united to different ſubſtances, and in different proportions.

Stahl has eſtabliſhed theſe important truths, chiefly by examining, by decompoſing, and by re-compoſing common ſulphur, and by demonſtrating from the moſt ſatisfactory experiments, that this ſulphur conſiſts of vitriolic acid united with the pureſt and ſimpleſt inflammable principle. We ſhall relate as ſhortly as we can the reſults of his reſearches upon this ſubject.

Nature probably forms, and combines daily, mineral ſulphur within the earth. This ſubſtance is abundantly diffuſed in many places, eſpecially where metallic minerals exiſt. Sulphur almoſt pure, called *native ſulphur*, is found in volcanos and in grottos, where it is ſublimed in form of tranſparent cryſtals. But the greateſt quantity of ſulphur which exiſts naturally is combined with metals in ores and eſpecially in pyrites. As ſulphur is fuſible and volatile, it is procured from theſe minerals by diſtillation and ſublimation. *See* SMELTING *of* ORES.

Sulphur, ſuch as it is in commerce and in arts, is of a pale yellow or citron color, of a diſagreeable and peculiar ſmell, which is rendered more ſenſible when the ſulphur is heated or rubbed. By rubbing, ſulphur is electriſed. Its ſpecific gravity is much greater than that of water, and leſs than that of earths and ſtones. It is brittle and pulverable; altho' it may alſo be eaſily ſoftened, as we ſhall afterwards obſerve.

Sulphur ſeems to be incapable of receiving any alteration from air or from water, ſeparately or conjointly, nor even from fire in cloſe veſſels. Sulphur, expoſed to heat in a ſubliming veſſel, is melted with a very gentle heat, and then is ſublimed, and adheres to the capital, forming ſmall very fine needle-like cryſtals, called *flowers of ſulphur*. This ſublimed ſulphur is eſſentially the ſame as that which has been only melted: and it may be thus ſublimed many times without alteration. If ſulphur, which has been expoſed to no more heat than ſufficient to melt it, be cooled very gradually, it cryſtallizes in form of many needles croſſing each other. Some of theſe pointed cryſtals may alſo be obſerved in the interior parts of the lumps of ſulphur which have been melted and caſt into cylindrical moulds, as they are commonly ſold; becauſe the center of theſe cylindrical rolls is more ſlowly cooled than the ſurface. Sulphur alſo gives this needle-like form to cinnabar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by expoſure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combuſtion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always blueiſh, not very luminous, and not accompanied with any ſoot or ſmoke, but with an acid vapor of a penetrating and ſuffocating ſmell. This vapor, confined by means of a glaſs bell, and received into the vapor of water, introduced for that purpoſe into the ſame bell, is called *ſpirit of ſulphur*, which we ſhall afterwards ſhew is the vitriolic acid, that is at firſt volatile and ſulphureous, from the ſmall quantity of inflammable principle that it ſtill retains, but which afterwards becomes pure vitriolic acid.

If, on the contrary, ſulphur is burnt in open air but very ſlowly, its flame is ſo little luminous, that it can be perceived only in the dark, like a ſmall bluiſh glimmering light; and ſo little ardent, that it cannot kindle the moſt inflammable ſubſtances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the ſulphur that is contained in gunpowder without kindling the powder. When this experiment is made, a tile muſt be equally heated and to a certain degree, that is, a little more than is requiſite for the ſucceſs of the experiment. Upon this tile, thus heated, ſome grains of gun-powder are thrown, to diſcover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is uſual. More powder is thrown on the tile, till this be ſo much cooled, that the powder does not fulminate, but only emits a white ſmoke. If the tile and powder be carried in this ſtate to a dark place, the vapor, which ſeemed to be a white ſmoke, will then appear to be a true flame, but very bluiſh and faint; which will continue till all the ſulphur of the powder be conſumed, if the tile remains ſufficiently hot for that purpoſe.

We may eaſily perceive, that when the ſulphur burns thus weakly and ſlowly, a part of its inflammable principle is diſſipated without inflammation, and that conſequently the acid which is diſengaged by that combuſtion, ought to be more volatile, penetrating, and ſulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile ſulphureous acid by burning ſulphur, as for the whitening of ſtuffs by the vapor of ſulphur, it muſt be burnt very ſlowly, as Stahl has well remarked.

As nothing remains after the burning of ſulphur, unleſs ſome extraneous body happens to be mixed with it; and as, during this combuſtion, nothing is perceptible but two matters, one of which is deſtroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that ſulphur is compoſed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this ſubſtance will render our knowledge of its nature and its principles more complete and accurate.

Sulphur heated ſo much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered ſolid; but in this experiment it acquires a conſiderable degree of ſoftneſs, which indeed only laſts a certain time; after which the ſulphur recovers its natural conſiſtence and brittleneſs.

Pure acids ſeem to have no action upon ſulphur, eſpecially in the humid way. But Mr. Beaumé has obſerved that if concentrated vitriolic acid be poured upon ſulphur, and heated to a certain degree, this ſulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which ſeems to ſhew ſome action of the acid upon the ſulphur. But this ſulphur is not in any other reſpect changed.

Alkalis fixed and volatile, and even calcareous earths, diſſolve ſulphur, render it more or leſs ſoluble in water, and form with it compounds called *livers of ſulphur*. The ſulphur may be ſeparated and precipitated, by means of an acid, from theſe ſubſtances; in which caſe, it appears as before, only much divided.

This experiment ſhews that ſulphur is not decompoſed by uniting with alkalis. Nevertheleſs the ſtrong fetid ſmell of liver of ſulphur, and the facility

cility of decompoſing ſulphur while it is thus united with an alkali, ſhew that, in this combination, the connexion of its parts are weaker than when it is uncombined. *See* LIVER *of* SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decompoſed by the combuſtion of this principle. But in this detonation we perceive only the two principles of ſulphur above-mentioned. Its phlogiſton, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the ſulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *ſal polychreſt of Glaſer.* This is completely proved in the experiment of the *clyſſus of ſulphur.* *See* CLYSSUS.

Sulphur unites eaſily with all metallic matters, excepting gold, platina, and zinc; at leaſt we have not found the means of uniting it with theſe, directly, and without ſome intermediate ſubſtance. The degrees of affinity with which ſulphur combines with thoſe metals to which it may be readily united, are different; for it not only unites more eaſily and abundantly with ſome than with others, but it alſo quits thoſe with which it has a leſs affinity, to unite with others to which it has a ſtronger affinity.

The affinities of ſulphur according to Mr. Geoffroy's table are, fixed alkali, iron, copper, lead, ſilver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's table, they are, iron, copper, tin, lead, ſilver, biſmuth, regulus of antimony, mercury, arſenic, and cobalt: gold and zinc are marked in this table as being incapable of uniting with ſulphur.

The compounds formed by ſulphur with different metals are different; but all of them poſſeſs a metallic luſtre, without any ductility: theſe combinations of ſulphur and of metals are very frequently found in a natural ſtate. Almoſt all the metals which we dig from the earth are naturally found combined with ſulphur, forming moſt of the ores and metallic minerals.

The properties of the combinations of ſulphur with metallic matters have been little examined, becauſe theſe combinations are not of any uſe; but, on the contrary, when they are found, they muſt be decompoſed, that the metals may be obtained ſeparately from the ſulphur. Nevertheleſs, we know not only that metals have different degrees of affinity with ſulphur; in conſequence of which property, ſulphur may be and actually is, in many metallurgical operations, ſeparated from ſome metals by means of others, to which it is more diſpoſed to unite; but we alſo know that ſulphur facilitates the fuſion of hard and difficultly fuſible metals, ſuch as copper and iron; and that, on the contrary, it renders the ſoft and fuſible metals, as tin and lead, leſs eaſily fuſible. Theſe ſingular effects ſeem to proceed from the difference of the affinity of ſulphur to the ſeveral metals.

Sulphur may be ſeparated from metallic matters by ſeveral methods. Firſt, as ſulphur is volatile, and as theſe metallic matters are fixed, or at leaſt leſs volatile than ſulphur, the mere action of fire is ſufficient to ſeparate ſulphur from moſt metals. As this method is ſimple, and not expenſive, it is generally employed to ſeparate ſulphur from ores; which effect is produced by the *torrefaction* or *roaſting* of theſe ores. We muſt, however, except the ore of mercury, or native cinnabar, and alſo the combinations of arſenic with ſulphur, which cannot be decompoſed without an intermediate ſubſtance, from the great volatility of mercury and of arſenic: although perhaps it would not be impoſſible to ſeparate the ſulphur from theſe compounds, without an intermediate ſubſtance, by a heat carefully applied, long continued, and with acceſs of air.

Secondly, ſeveral combinations of ſulphur with metals may be decompoſed by means of acids, which diſſolve the metallic matter, without attacking the ſulphur. But in ſeveral of theſe compounds, the ſulphur defends the metal from the action of the acids; and this ſeparation by acids does frequently not ſucceed, or ſucceeds only imperfectly. Crude antimony is one of the ſulphurated metallic ſubſtances from which ſulphur may moſt eaſily be ſeparated by means of aqua regia. This menſtruum ſeizes readily the regulus of antimony contained in mineral antimony, and ſeparates from it the ſulphur, which then appears in form of a white powder.

Laſtly, we may, as we have already ſaid, ſeparate ſeveral metals from ſulphur by means of other metals, to which the ſulphur has a greater affinity. This ſeparation is practiſed in ſeveral operations, as in the *dry parting*, the *purification of gold by antimony*, the *decompoſition of cinnabar*, of *orpiment*, and of *crude antimony. See the articles* Essay *of* Ores; Ores; Pyrites; Smelting *of* Ores; *and all the articles of the ſeveral metals and ſemi-metals:*

Oils and oily matters, of whatever nature, are all capable of acting upon ſulphur, and of diſſolving it. Several ſolutions of ſulphur in eſſential oils are uſed in pharmacy, which have been named from the oils employed; as *terebinthinated balſam of ſulphur*, and *aniſated balſam of ſulphur*; and other ſolutions have been made of ſulphur in expreſſed ſweet oils, as that in the oil of nuts, called *Rulland's balſam of ſulphur*.

Sulphur cannot be diſſolved in oils, according to Mr. Beaumé, without a heat ſufficient to melt it. A larger quantity of ſulphur is kept diſſolved in the oil while hot than when cold; and accordingly when oil has been ſaturated with ſulphur by means of heat, a part of the ſulphur ſeparates from it when it cools, in the ſame manner as many ſalts kept diſſolved in hot water are cryſtallized when the water becomes cold. The analogy betwixt the ſalts and ſulphur in theſe inſtances is alſo obſervable in this reſpect, that when the oil in which the ſulphur is diſſolved is very gradually cooled, the ſulphur cryſtallizes regularly, as ſalts do in ſimilar circumſtances.

Sulphur is not decompoſed by the union which it contracts with oils, when no more heat is applied than is neceſſary for the ſolution. For the ſulphur, when ſeparated from the oil, is found to be poſſeſſed of all its properties. It appears, however, that the connexion of its principles is in ſome meaſure altered by this combination; at leaſt, if we may judge from the color and ſmell of the balſams of ſulphur which are different from thoſe of the ſulphur, or of the oil.

But when the balſams of ſulphur are diſtilled with a heat capable of entirely decompoſing them, the ſulphur itſelf is then alſo decompoſed. For according to an experiment made by Homberg, and ſome other chemiſts, the ſame principles are obtained by this diſtillation continued till the matter in the retort be dry, as are obtained from a combination of pure vitriolic acid with oils. Theſe principles are, firſt, a portion of oil, when the oil of which the diſtilled balſam is compoſed was an eſſential oil; then ſome volatile ſulphureous acid, which is at firſt watery, and afterwards becomes ſtronger; along with this acid more oil riſes, which becomes more and more thick towards the end of the diſtillation; and laſtly, when the retort has been red-hot, nothing remains but a fixed coal.

From the above-mentioned products we find, that the ſulphur and part of the oil are decompoſed in this diſtillation. The vitriolic or ſulphureous acid certainly proceeds from the ſulphur: for no quantity of that acid can be obtained from any kind of oil, nor from any pure vegetable or animal oily matter. The water contained in this ſulphureous acid is evidently a part of the water which is a principle of the oil: for the vitriolic acid of the ſulphur being in a ſtate perfectly concentrated and dry, as ſhall be afterwards ſhewn, could not otherwiſe contain ſo much water as it does in this operation. Laſtly, the coal which remains after the operation is a portion of the earth that is a principle of the oil, intimately united with ſome of the inflammable principle either of the oil or of the ſulphur, or moſt probably of both.

In this mutual decompoſition of ſulphur and oil, the concentrated acid of the ſulphur ſeems to attack the watery principle of the oil, while its phlogiſton, which by this new union loſes much of its adheſive power, is partly diſengaged, and confounded with the phlogiſton of the oil. Thus the ſulphur is changed into volatile ſulphureous acid. And probably alſo a certain quantity of inflammable principle is diſengaged in this experiment, and is diſſipated in vapors. Such appear to be the phlogiſtic vapors, which, kindling at once, produce the terrible exploſions that ſometimes happen when the combinations of oil and of ſulphur are careleſly heated. Hoffman relates a ſingular inſtance of an exploſion of this kind, which happened in a laboratory, where balſam of ſulphur had been left in a matraſs upon the fire.

Spirit of wine does not act ſenſibly upon ſulphur, unleſs theſe two ſubſtances be applied to each other in the ſtate of vapor, as the Count de Lauraguais diſcovered. Many combinations, now believed to be impoſſible, might be effected by employing the moſt powerful means in chemiſtry; namely, an extreme diviſion and ſeparation of integrant parts, as the Count de Lauraguais has done in the abovementioned fine experiment. By this means, chiefly, we may arrive at great diſcoveries. From the above-mentioned properties of ſulphur we learn, that this ſubſtance is compoſed of vitriolic acid and phlogiſton. Stahl demonſtrated this important truth ſo clearly and compleatly, as to ſhew the true ſtate, and even the proportion of the principles of ſulphur, not only from its analyſis, but alſo by its artificial compoſition, of which we ſhall now ſpeak.

The proceſs by which this chemiſt made ſulphur exactly ſimilar to native ſulphur, conſiſts in mixing and melting together in a crucible equal parts of fixed alkali and of vitriolated tartar, to which is added a quantity of powdered charcoal equal to a fourth part of the weight of the ſalts. The matter is to be ſtirred with an iron rod, that the charcoal may be well mixed with the ſalts; the crucible is to be covered; and a pretty ſtrong heat is to be ſuddenly applied, and continued during a very ſhort time. The crucible is then to be removed from the fire, and the melted matter is to be poured upon a ſtone previouſly greaſed. This matter, which ſparkles when it is poured, is coagulated by cold, and becomes a brittle maſs, of a deeper red color than ordinary liver of ſulphur; but it has the ſmell, the ſolubility, the deliqueſcency, and all the other properties of liver of ſulphur. By diſſolving it in water, and by adding any acid to the ſolution, an artificial ſulphur will be precipitated, which being collected and dried, is found not to differ from natural ſulphur.

The color of this dry liver of ſulphur is redder than that of the ordinary preparation of that name; and when diſſolved in water, its ſolution is of a deep green color, in which reſpect alſo it differs from the ordinary liver of ſulphur. Theſe differences proceed from ſome foreign matter united with the liver of artificial ſulphur; and this foreign matter is a part of the charcoal employed in the proceſs for making the ſulphur. For the whole quantity of charcoal added not being converted into ſulphur in this proceſs, ſome part of it is diſſolved by the liver of ſulphur, as ſoon as this is formed; charcoal being ſoluble in liver of ſulphur, as the younger Mr. Rouelle has ſhewn.

We ſhould be much miſtaken if we believed, that the ſulphur obtained in this operation exiſted ready formed in any of the ſubſtances employed, and that it is only extracted from theſe. Glauber had, before Stahl, performed this operation, by employing his *ſal mirabile* inſtead of vitriolated tartar; but from his ignorance of the true theory, he fell into this miſtaken opinion. Boyle alſo, having procured ſulphur by diſtilling to dryneſs a mixture of vitriolic acid and oil of turpentine, did not believe that he had produced this ſulphur, but only that he had ſeparated it from the ſubſtances employed. On the contrary, we know certainly from many proofs, that not a particle of ſulphur exiſts in vitriolic acid, nor in neutral vitriolic ſalts with baſis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and conſequently the ſulphur obtained in theſe operations is a new product, reſulting from the union of the vitriolic acid with the inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with the vitriolated tartar in this proceſs is not abſolutely neceſſary; for ſulphur may be produced merely from any vitriolic ſalt with any inflammable matter, made red-hot together: but the alkali is uſeful in this proceſs, by facilitating the fuſion of the vitriolated tartar, and by preventing the diſſipation and combuſtion of moſt of the ſulphur, as ſoon as it is formed. This alkali unites with this ſulphur, and forms a liver, in which the ſulphur is leſs diſpoſed to burn, and be diſſipated, than when it is not engaged with any fixed and incombuſtible body.

Although, rigorouſly ſpeaking, the vitriolic acid itſelf, when diſengaged, and treated properly with any combuſtible body, can always produce ſulphur; nevertheleſs, in this operation, an acid engaged in ſome baſis to which it adheres ſtrongly ought always to be employed; ſuch is the acid in vitriolated tartar, in Glauber's ſalt, and even in almoſt all neutral vitriolic ſalts with earthy and metallic baſes; becauſe vitriolic acid cannot contract with the inflammable principle the intimate union which is requiſite for the production of true ſulphur, excepting it be deprived of all the water that is not neceſſary to its ſaline eſſence; that is to ſay, in its higheſt degree of concentration, and even in a dry ſtate. Beſides, if a red heat be not abſolutely neceſſary to effect this combination, as the ſulphur formed in the ſolution of ſome metallic matters by vitriolic acid ſhews, vertheleſs very uſeful. But when a diſengaged vitriolic acid is employed; as, for inſtance, when a mixture of this acid with an oil is diſtilled; the greateſt part of the acid is converted into volatile ſulphureous acid, while any moiſture remains in the mixture, and the ſulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogiſton of the earthy coal of the oil, forms the ſulphur.

Hence, ſulphur may be more copiouſly and quickly made by applying to a coal vitriolic acid engaged in ſome baſis, which renders it ſo fixed that it may, by fire, be deprived of all ſuperfluous water, and even be made red-hot, than by employing this acid in any other manner. Accordingly Stahl's proceſs is the beſt. Theſe conſiderations on the beſt method of making ſulphur are of little value, becauſe natural ſulphur is plentiful and cheap. But the diſcovery that ſulphur can be thus made, and the theory which Stahl has given concerning this ſubject, are very important. For from thence we not only learn the nature of ſulphur, of which we had an imperfect, and even falſe, idea; but, what is much more valuable, we may thence draw a number of very important and very general inferences, the chief of which we ſhall now mention.

Firſt, vitriolic acid and the inflammable principle cannot form ſulphur by combining together, unleſs they both be deprived of all moiſture, and be perfectly dry. Hence no inflammable body which contains in its compoſition water, ſuch as oils and ardent ſpirits, can form with this acid, ſulphur, but only a volatile ſulphureous acid, till theſe inflammable matters be decompoſed, and reduced to a ſtate of coal, which is one of the dry combinations of the inflammable principle.

Secondly, the inflammable principle of all combuſtible bodies is always capable of forming ſulphur with the vitriolic acid, provided it be, or can be made, dry. Thus ardent ſpirits, oils, and oily matters; or rather the coals of all theſe ſubſtances, and all combuſtible metals, do always form ſulphur when treated properly with vitriolic acid; and whatever the nature of the combuſtible body be which transfers the phlogiſton to the acid, the ſulphur reſulting from it is always the ſame, and always perfectly ſimilar to natural ſulphur. Hence an important propoſition is inferred, that only one inflammable principle exiſts, which is always the ſame, whether it reſides in reſins, in bitumens, in oils and fat, in coals, or in metals. For if the inflammable principle of all theſe combuſtible bodies was not the ſame principle, theſe bodies might form different ſulphurs with vitriolic acid, which we find from experience they cannot do.

Thirdly, vitriolic acid always quits any body with which it happens to be combined, when it can unite with the inflammable principle of any other body, and with this principle forms ſulphur when it is properly applied. Hence, this acid has a greater affinity with the inflammable principle than with any other ſubſtance; and hence we may diſcover, by means of phlogiſton, the vitriolic acid, with whatever ſubſtances it may be combined; and reciprocally we may, by means of vitriolic acid, diſcover the inflammable principle in all bodies in which it exiſts in a combuſtible ſtate.

Fourthly, the principles and properties of ſulphur being known, we may deduce from theſe properties a more accurate knowledge of the particular nature of the inflammable principle, by comparing the differences between ſulphur, volatile ſulphureous acid, and pure vitriolic acid. From this compariſon we find that the ſmell and color of ſulphur, its volatility, its conſtant dryneſs, its unſolubility in water, which properties do not belong to vitriolic acid, are produced by the inflammable principle, that poſſeſſes all theſe qualities in itſelf, or that is, at leaſt, capable of communicating them to the compounds in the combination of which it enters. *See the Article* PHLOGISTON.

Fifthly, we have reaſon to believe that the inflammable principle poſſeſſes eminently the abovementioned properties; for we know that the quantity of it in ſulphur is much leſs than the quantity of the vitriolic acid. Stahl has made a fine experiment to diſcover nearly the proportion of the two principles of ſulphur. This experiment conſiſts in putting a quantity of powdered liver of ſulphur upon an earthen-ware plate, and placing this plate upon a fire ſo gentle that the liver of ſulphur ſhall not be melted, nor even ſo ſoftened that it can run into lumps. This powder muſt be ſtirred, and the fire muſt be encreaſed towards the end, till no ſmell be perceived. The remaining matter is to be diſſolved in water, and by cryſtallization a very pure vitriolated tartar is formed.

In this operation, the inflammable principle of the ſulphur is gradually diſſipated without any ſenſible combuſtion, and its acid combines, or remains combined, with the alkali of the liver of ſulphur. But we muſt obſerve, that to render this experiment exact, and to draw from it accurate concluſions, the following conditions are required: 1ſt, we muſt know preciſely the quantity of ſulphur contained in the liver of ſulphur employed; 2dly, the liver ought to contain rather too much than too little fixed alkali, that there may be certainly enough of it to ſaturate all the acid of the ſulphur; laſtly, no part of the ſulphureous acid muſt eſcape during this decompoſition; and therefore no ſmell of this acid, but only that of the liver of ſulphur, which is very different, ought to be perceived. To prevent this diſſipation of volatile acid, we muſt proceed very ſlowly; and the operation accordingly requires a long time. Mr. Brandt, who has carefully repeated it, found from the quantity of vitriolated tartar obtained by this method, that, in ſulphur, the proportion of inflammable principle is to that of the vitriolic acid as three to fifty; that is, that the ſulphur contains only one-ſixteenth of its weight of inflammable principle.

Such is the ſtate of our actual knowledge concerning the nature and principles of ſulphur, which Stahl has rendered very compleat and accurate. We find that ſulphur is a peculiar combination of the pureſt inflammable principle with vitriolic acid; that not a particle of oil is contained in it; that it is therefore very different from bitumens, with which it has been long confounded; that, ſtill more improperly, the name of ſulphur has been given to all other inflammable bodies, which are entirely different from it; that we ought therefore to confine the name of ſulphur to the compound formed of pure vitriolic acid and pure phlogiſton, unleſs we would apply it, as the ancient chemiſts have done, to the inflammable principle itſelf, which they called the *principal ſulphur*; but in this caſe we ought to give another name to mineral ſulphur.

Let us remark, nevertheleſs, on the ſubject of the name *ſulphur*, that as other acids beſides the vitriolic can alſo contract an intimate union, and form compounds with pure phlogiſton, this name may be generally applied to all compounds of pure acid and phlogiſton, which may be diſtinguiſhed from each other by adding the name of the acid; as *vitriolic ſulphur*, *nitrous ſulphur*, and *marine ſulphur*, if any ſuch ſulphur does exiſt: but let us alſo remark upon this ſubject, that we can give this name of *ſulphur* to thoſe compounds only which do not contain any oil; this condition being eſſential to the ſulphureous combination; and conſequently, that we cannot admit of *acetous ſulphur*, of *tartareous ſulphur*, or of others of this nature containing vegetable acids, which cannot ever form a truly ſulphureous combination, on account of the oil which enters into their compoſition as an eſſential principle. *See the articles* ACID (VITRIOLIC), ACID (VOLATILE SULPHUREOUS), DETONATION *of* NITRE, LIVER *of* SULPHUR, *and* PHLOGISTON.

The uſes of ſulphur are conſiderably extenſive in chemiſtry, in medicine, and in arts. The liver of ſulphur is employed in chemiſtry for ſeveral ſolutions, which may be ſeen at the article LIVER *of* SULPHUR. Sulphur is alſo uſeful for ſeveral fuſions, precipitations, and ſeparations of metals and minerals, as we have already mentioned. Laſtly, as ſulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practiſed, of extracting from it this acid, by burning ſulphur in cloſe veſſels with the addition of ſome nitre, and by an operation ſimilar to that of the clyſſus. *See* CLYSSUS.

Sulphur is employed in medicine, both internally and externally, for aſthmatic diſeaſes of the breaſt, and for ſeveral diſeaſes of the ſkin of the nature of the itch. The internal preparations of ſulphur are, flowers of ſulphur, waſhed ſulphur, magiſtery of ſulphur, tablets, balſams, livers of ſulphur, and others, in ſome of which this ſubſtance is not altered, but only purified and divided, and in others, is combined and aſſociated with other ſubſtances; without reckoning the ſulphureous combinations of antimony and of mercury.

Some phyſicians and chemiſts, conſidering that ſulphur is unſoluble in water, and capable of reſiſting the action of moſt menſtruums, have advanced that it can produce no effect when taken internally, ſingle and unaltered: but this aſſertion ſeems to be without foundation; for we are certain that the ſweat and perſpiration of thoſe who take ſulphur internally have a ſmell evidently ſulphureous. Beſides, ſulphur is much more ſoluble than is generally believed. It is attacked by all oily and ſaponaceous ſubſtances, and conſequently by almoſt all animal liquors.

We cannot eaſily form a very diſtinct and clear idea of the manner in which ſulphur acts internally upon our bodies; but from obſervations made upon its effects, it appears to be dividing, ſtimulating, and ſomewhat heating: it principally acts upon the perſpirable parts of the body, the chief of which are the ſkin and lungs; and from this property, it is particularly uſeful in ſome diſeaſes of theſe parts.

Sulphur is alſo a powerful repellent, as appears from its curing ſeveral kinds of itch merely by external application in form of ointments and pomatums.

Several mineral waters, which are drank, or uſed as baths, for ſome diſeaſes, owe their good qualities to ſulphur contained in them. Such are the waters of Cauterets, of Mont D'or, of Aix-la-Chapelle, and of Saint-Amant. Accordingly, theſe waters are employed in ſeveral diſeaſes of the breaſt and of the ſkin. Laſtly, ſulphur combined with other ſubſtances may contribute to their medicinal powers. *See the articles* Balsam *of* Sulphur, Cinnabar, Ethiops Mineral, Mineral Waters, Liver *of* Sulphur, Kermes Mineral.

Sulphur is alſo uſed in ſeveral arts. By means of it fine impreſſions of engraved ſtones are taken. Matches are formed of it; and its utility as an ingredient in the preparation of gun-powder and fire-works is well known. Laſtly, it is uſed for whitening wool, ſilk, and many other matters expoſed to its vapor during its combuſtion, the colors and redneſs of which could not be deſtroyed by any other ſubſtance, but are quickly chaced by this acid vapor.

DCLXXV. SULPHUR (GOLDEN) *of* ANTIMONY. Golden ſulphur of antimony is a mixture of ſulphur and regulus of antimony, of an orange color, which is obtained by diſſolving the ſcoria of regulus of antimony, and by precipitating this ſolution by means of an acid.

We may ſee at the article Regulus *of* Antimony, that this ſcoria is a liver of ſulphur, containing a certain quantity of the reguline part of antimony. When therefore this antimoniated liver of ſulphur is diſſolved in water, and when any acid is added to this ſolution, the acid ſeizes upon the alkali of the liver of ſulphur, by means of which the ſulphureous and reguline parts of the antimony were kept ſuſpended in the water, and at once precipitates both theſe.

Although this precipitate be compoſed of ſulphur and regulus of antimony, as crude antimony alſo is, its properties are nevertheleſs very different from thoſe of this mineral. The precipitate has no metallic color or appearance, and is beſides poſſeſſed of a powerful emetic quality, which the antimony has not. Theſe differences proceed from the ſulphur of the precipitate not being united with the reguline part in the ſame manner, nor ſo intimately, as in crude antimony. In the golden ſulphur, the reguline part is only *mixed* with the ſulphur, and is in a great meaſure diſengaged and uncombined; whereas in crude antimony, it is intimately connected and united with the ſulphur.

Golden ſulphur has ſome reſemblance to kermes mineral: but it differs eſſentially in ſome circumſtances, namely, that a ſmall portion of fixed alkali remains united with the kermes when well prepared, that is, not too much waſhed, and that the proportion of ſulphur is greater in kermes than in the golden ſulphur. To be convinced of theſe differences, we need only to attend to the circumſtances which accompany the precipitation of theſe two ſubſtances. Kermes is precipitated ſpontaneouſly without addition of any acid, and merely by the cooling of the ſolution of the antimoniated liver of ſulphur which contains it: it is therefore compoſed of the reguline part, but eſpecially of the ſuperabundant quantity of ſulphur, which the alkali cannot keep diſſolved, but by means of a heat almoſt equal to that of boiling water: whereas the ſolutions of antimoniated liver of ſulphur, not only that of kermes itſelf, but alſo that of the ſcoria of the regulus of antimony which has depoſited its kermes by cooling, contain no more ſulphur than the alkali can keep diſſolved without heat, which quantity is therefore leſs than in the kermes. Beſides, the acid neceſſary for the precipitation of the golden ſulphur ſeizes all the alkali; whereas a little of it always adheres to the kermes during its precipitation.

The golden ſulphur of antimony was much employed when preparations of antimony were firſt introduced into medicine, but is now pretty much neglected; and juſtly, becauſe the kermes and emetic tartar produce the ſame effects more gently and more uniformly. *See* ANTIMONY *and* KERMES (MINERAL).

T.

DCLXXVI. TALK. *See* MICA.

DCLXXVII. TAR. *See* PITCH.

DCLXXVIII. TARTAR. Tartar is a concrete, oily, vegetable acid, which is depoſited and is cryſtallized in liquors that have undergone the ſpirituous fermentation. It is a kind of eſſential ſalt of wine.

Probably wines of all kinds depoſite a greater or leſs quantity of tartar; but the wine of grapes is one of thoſe which furniſh the moſt of it, and the tartar of this wine is almoſt the only one that is employed or known.

All wines of grapes do not furniſh an equal quantity of tartar. Some of them depoſite it abundantly, and others but a ſmall quantity only. Sometimes a longer and ſometimes a ſhorter time is required for the depoſition of tartar. Generally a long time is required, and alſo an inſenſible kind of fermentation, which continues in the wine a long time after the ſigns of the ſenſible ſpirituous fermentation have ceaſed. *See* WINE.

The tartar is depoſited on the ſides of the caſks containing wine. On theſe a hard cruſt is formed, which becomes more and more thick; and as a portion of the fine dregs of the wine adheres to this cruſt, the tartar of white wine is of a greyiſh-white color, and is called *white tartar*; and that of red wine has a red color, and is called *red tartar*.

Tartar, when ſeparated from the caſks on which it is formed, is mixed with much heterogeneous matter, from which it is purified for the purpoſes of medicine and of chemiſtry. This purification of tartar is performed at Montpellier, and conſiſts (as we find from a Memoir of M. Fizes, Profeſſor of Medicine at Montpellier, printed amongſt the Memoirs of the Academy for the year 1725) in boiling tartar in pure water, in filtrating this water, and in allowing the ſaline matter to depoſite by cold. By this firſt operation, the groſſer impurities which adhere but ſlightly to the tartar are ſeparated: but the cryſtals obtained by this operation are ſtill red, and charged with an oily matter extraneous to the tartar.

From this extraneous matter the tartar is purified by boiling it in water in which clay is diffuſed. By a ſecond filtration and cryſtallization, very pure and white cryſtals of tartar are obtained; but they are ſmall and ill-ſhaped, from the quickneſs of their formation.

This cryſtallization is partly performed by evaporation, and partly by cold. The part which cryſtallizes by evaporation forms a ſaline cruſt upon the ſurface of the liquor, called *cream of tartar*; and the part which cryſtallizes by cold forms ſmall irregular cryſtals, called *cryſtals of tartar*; but the name of cream of tartar has prevailed over the latter; ſo that it is at preſent applied alſo to cryſtals of tartar, and ſignifies in general purified tartar.

Cream of tartar has a taſte ſenſibly acid; it reddens the blue colors of vegetables; it may be ſaturated by uniting with any of thoſe ſubſtances which are capable of forming with acids neutral ſalts; and it may be afterwards ſeparated from theſe ſubſtances, and may recover its former appearance. Accordingly, we are certain that this ſaline matter is an acid. Its property by which it is concrete and cryſtallizable, it receives from a portion of earth and oil, with which it is intimately combined, and which approximate it to the nature of neutral ſalts, eſpecially in what concerns the cryſtallizable quality and the ſolubility of theſe ſalts.

Tartar, although acid, is not very ſoluble in water; it is even much leſs ſoluble than moſt of the perfectly neutral ſalts. According to Mr. Spielman's experiment, an ounce of diſtilled water can diſſolve only three grains of cream of tartar, with the heat of fifty degrees of Fahrenheit's thermometer, which is equivalent to the tenth degree of Mr. Reaumur's. By help of a boiling heat, water diſſolves much more tartar; but this tartar cryſtallizes very quickly when the water ceaſes to boil. The oily part of the tartar ſeems to be the chief cauſe of its difficult ſolubility in water.

Tartar is in a great meaſure decompoſed and totally changed by the action of fire. If cream of tartar be diſtilled in a retort with a naked fire, a little phlegm will firſt riſe with a gentle heat. When the fire is gradually encreaſed, which muſt be done very cautiouſly, on account of the prodigious quantity of air that is diſengaged during this diſtillation, an acid ariſes in form of white vapors, which are accompanied with an oil, at firſt thin, but afterwards more and more colored and empyreumatic. In the retort there remains a coal, ſtrongly alkaline, equal in weight to two-thirds of the tartar employed.

The acid obtained in this diſtillation is indeed oily, and therefore retains the character of a vegetable acid; but it is very different from the tartar itſelf. It is no longer cryſtallizable; it is only an oily empyreumatic acid, ſimilar to what is obtained from all other vegetables by diſtillation in a naked fire. Theſe differences muſt be attributed to the portion of oil and of earth, which are ſeparated from this acid by diſtillation. As to the reſiduum of coal, the fixed alkali, which it contains ready formed, is remarkable, conſidering that here there is no incineration in open fire, which is generally neceſſary for the production of alkali from almoſt all other vegetables. The cauſe of this difference probably is, that the acid of tartar is almoſt entirely changed into fixed alkali, is more diſpoſed to be alkaliſed than any other vegetable acid, whether this diſpoſition proceed from the quantity of earth and oil which are intimately mixed with it, or from ſome change produced upon it by fermentation. Mr. Spielman thinks, with much probability, that acids are changed into alkalis by the ſubſtraction of a part of their aqueous principle: and the nature and proportion of the conſtituent parts of tartar appear to be very proper to favour this ſubſtraction of the watery principle by the action of fire. This ſubject is ſtill obſcure, and would require a more profound examination.

DCLXXIX. TARTAR EMETIC, *or* STIBIATED TARTAR. Thus is named the compound formed of the acid of tartar combined with the metallic part of antimony, when this is half deprived of its phlogiſton. It is the beſt and moſt uſed of all the emetic preparations of antimony, becauſe the metallic part of this mineral, which gives the emetic quality, is in a ſaline ſtate, and is perfectly ſoluble in water.

This preparation has been juſtly ſubſtituted for the golden ſulphur, for the regulus, for the liver and glaſs of antimony, and for the powder of Algaroth. It is infinitely preferable to theſe preparations for the reaſons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we conſult the ſeveral diſpenſatories, we ſhall find very different proceſſes directed: the cream of tartar is employed by all, but ſome of them require that it ſhould be boiled with the liver of antimony, others with the glaſs of antimony, and laſtly, ſome with both theſe preparations. The proportion alſo of the ingredients, the length of time of boiling, the method of cryſtallizing and drying the ſalt after it has been boiled, are different in different diſpenſatories. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are alſo certain that the emetic tartars obtained by theſe ſeveral proceſſes are ſometimes more and ſometimes leſs emetic; which difference is certainly a great inconvenience for ſo important a medicinal preparation as this is.

Probably this diverſity has been occaſioned by perſons not conſidering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being diſſolved by the acid of tartar, and forming with it a kind of ſoluble tartar, a true neutral ſalt, no leſs capable of a very exact ſaturation than the vegetable ſalt, the ſalt of Saignette, and all the other ſoluble tartars. For this ſaturation being a fixed point, and eaſily to be found, would probably have been univerſally preſcribed, as is done for all other neutral ſalts, if it had been well known to have occurred in this inſtance. But as it is now ſufficiently aſcertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally ſtrong. Upon this ſubject we ſhall add ſome obſervations.

Firſt, although regulus of antimony be eſſentially emetic, it nevertheleſs produces leſs effect than the liver or the glaſs of antimony, becauſe it is leſs ſoluble. Theſe two preparations, which are only the metallic earth of antimony deprived of a part of phlogiſton neceſſary to the reguline ſtate, are for that reaſon more eaſily ſoluble by acids than the regulus, and are conſequently more emetic. But the glaſs is ſtill more emetic than the liver, becauſe it has leſs phlogiſton; and it accordingly ſeems to be the moſt emetic, and moſt ſoluble in acids, of all the preparations [illegible] neral.

Secondly, the end propoſed in making emetic tartar, [illegible] emetic preparation of antimony, in which the metallic earth is [illegible] acid, and is ſoluble in water by means of that acid, and thus is [illegible] the inconveniences of the ancient antimonial emetics, the glaſs [illegible], &c. The principal inconvenience of theſe emetics is, that their [illegible] very uncertain. Sometimes theſe effects are not ſufficiently ſtrong, [illegible] more frequently too violent. Theſe differences of the ſame medicine [illegible]aration, given in the ſame doſes, ſhew that the circumſtances on which [illegible] action depends are variable. They cannot act internally, till they are [illegible]d: they can only be diſſolved by the acid or other liquors of the body that are capable of attracting them: But the quantity and ſtrength of theſe diſſolving liquors in the body are very variable, according to the different conſtitutions and ſtates of the alimentary canal. Beſides, the greater or leſs diviſion of theſe antimonial preparations favors more or leſs their ſolution in the body. We need not therefore wonder that their emetic effects ſhould be ſo variable and uncertain.

Theſe inconveniences are avoided by giving a ſaline quality to antimonial emetics, by uniting them with the acid of tartar. They then become entirely ſoluble in water by means of this acid; and the whole quantity of them which is adminiſtered produces conſtant and uniform effects: hence emetic tartar is preferable to all other antimonials that are not in a ſaline ſtate. But this preparation alſo muſt be more or leſs emetic, according to the quantity of reguline or metallic earth which it contains. Accordingly, Mr. Geoffroy found by examination of ſeveral emetic tartars, that an ounce of the weakeſt of theſe contained from thirty to ninety grains of regulus, that an ounce of moderate ſtrength contained about 108 grains, and that an ounce of the ſtrongeſt kind contained 1[illegible] grains of regulus. The detail of his experiments may be ſeen in the Memoirs of the Academy for the year 1734.

Theſe differences of ſtrength muſt proceed from the different methods employed to prepare the emetic tartars, and from the more or leſs perfect ſaturation of the acid of tartar.

M. Beaumé affirms from experiment, that this acid may be eaſily ſaturated with the reguline part of antimony: and as the glaſs of antimony is the moſt emetic and moſt ſoluble of all the antimonial preparations made by fire, we ought to prefer it to all others in the preparation of a perfectly neutral antimonial ſoluble tartar. For this purpoſe, we muſt mix together equal parts of cream of tartar and of porphyrized glaſs of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling muſt be continued gently, till there is no longer any effervefcence, and till the cream of tartar be entirely ſaturated. The liquor is to be filtrated; and upon the filter we may obſerve a certain quantity of ſulphureous matter, together with ſome undiſſolved part of the glaſs of antimony. When the filtrated liquor is cooled, fine cryſtals will be formed in it, which are a ſoluble tartar perfectly ſaturated with glaſs of antimony. The cryſtals of this ſalt have the form of triangular pyramids (a). They are tranſparent while they are moiſt; but by expoſure to a dry air, they loſe a part of the water of their cryſtallization, and become opake and white.

(a) The author probably means pyramids, the baſis of each of which is a triangle: for every pyramid muſt evidently have, at leaſt, four ſolid angles.

As the perfect ſaturation of acids requires conſtantly a determinate quantity of any ſubſtance which they can diſſolve, we ſhould be certain, by ſaturating compleatly cream of tartar with glaſs of antimony, that the emetic tartar thus prepared would conſtantly contain the ſame proportion of emetic antimonial parts. The cryſtallizing and draining of neutral ſalts in general, is a good method for obtaining them in their moſt perfect ſtate: accordingly this ſalt ought to be firſt cryſtallized; but as by expoſure to the action of air it is apt to loſe ſome of the water of its cryſtallization, it ought, immediately after it has cryſtallized, to be well dried; and then it would remain unchanged. I have frequently adminiſtered emetic tartar thus prepared, and I have always obſerved, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the conſtitution of the patients.

Authors who have given receipts for the preparation of emetic tartar, have differed, as we have obſerved, not only as to the kinds and proportions of the antimonial preparations which they direct to be boiled with cream of tartar, but alſo as to the duration of the boiling. Some of them require that the boiling ſhould laſt twelve hours, and others only a few inſtants, believing with Hoffman, that this ſalt is ſuſceptible of decompoſition and of loſing its emetic quality by a long continued boiling. Mr. Beaumé has determined this matter by well-conducted experiments, which ſhew that emetic tartar, like other metallic ſalts, is capable of being decompoſed by other metals to which its acid has a ſtronger affinity than the metallic baſis, and that iron particularly is capable of producing this effect upon emetic tartar; ſo that if it be boiled a long time in an iron veſſel, it is actually decompoſed, and the liquor is gradually changed into a tartariſed tincture of Mars. But Mr. Beaumé alſo found that emetic tartar may be boiled during any length of time in veſſels made of ſilver or of glaſs, without being decompoſed.

The reſults of theſe experiments of Mr. Beaumé are, 1. That any veſſels ought not to be employed in the preparation of emetic tartar; that eſpecially iron, and even copper, ought to be avoided, for this latter metal is found alſo to act a little upon emetic tartar; and that veſſels of ſilver or of glaſs ought to be uſed. 2. That as the intention of the operation is to ſaturate perfectly the cream of tartar, the boiling muſt be continued till this ſaturation be effected, which requires a long time when the glaſs of antimony is groſly pounded, but a much ſhorter time when it is well porphyriſed, as Mr. Beaumé practiſes.

We muſt acknowledge that emetic tartar, prepared by thus ſaturating completely the acid of tartar with glaſs of antimony, muſt be infinitely more uniform in its effects, than what is obtained by any of the other proceſſes hitherto practiſed. Nevertheleſs, when we reflect on the nature of the glaſs of antimony, we cannot affirm that this emetic preparation, notwithſtanding its perfect ſaturation, muſt always be of equal ſtrength. Glaſs of antimony is made by fuſing the grey calx of antimony, calcined to a certain degree. We know alſo, that if it be too little calcined, we ſhall obtain an opake matter, that reſembles the liver more than the glaſs; but that if it be too much calcined, it cannot be vitrified, nor even fuſed, by the moſt intenſe heat. But between the degree of calcination which is ſufficient to give an opake fuſed matter, and the degree when it begins to be unfuſible, there are many intermediate degrees of calcination, all of which are ſufficient to produce glaſſes of antimony; but theſe glaſſes differ in degree of tranſparency, intenſity of color, and fuſibility, according as the calcination has been more or leſs compleat. We cannot doubt that different glaſſes of antimony muſt be more or leſs emetic, and that perhaps different quantities of theſe glaſſes are required for the perfect ſaturation of the acid of tartar. Beſides, we are not only ignorant of the degree of calcination which renders the glaſs moſt emetic; but alſo, if we did know it, we have no certain method of attaining it preciſely.

Hence, we are not certain that emetic tartar, prepared by ſaturating tartar with glaſs of antimony, has always an uniform and conſtant emetic power. Theſe conſiderations have determined me to ſearch, among the ſeveral preparations of antimony, for one which ſhould have the ſame advantages that glaſs of antimony has, of being convertible into a neutral ſalt by means of tartar, without the inconveniences of its uncertain degrees of emetic ſtrength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of anſwering theſe intentions.

This preparation, which was formerly employed as an emetic, has been juſtly rejected with the other antimonials that have not a ſaline quality, becauſe it has the ſame inconveniencies as theſe have. It occaſioned accidents ſo terrible, that ſome phyſicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But theſe fatal effects do not prevent the poſſibility of rendering it a good remedy by a proper preparation; in the ſame manner as glaſs of antimony, which given ſingly produced much miſchief, has ſaved many lives ſince it was converted by its union with tartar into a moſt efficacious remedy.

Two cauſes concur in rendering the powder of Algaroth a violent and uncertain remedy. The firſt is common to it with glaſs of antimony, and with all the other antimonial preparations that are not ſaline; and is, its want of ſolubility in water, for the reaſons that we have aſſigned. The ſecond cauſe of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of cauſtic quality. But both theſe cauſes of the bad effects of this preparation may be eaſily and certainly removed. For, by waſhing it with a little fixed alkali, all the acid may be ſeparated. And I have found from experiments, that the powder thus waſhed is altogether ſoluble by cream of tartar, and of being thereby convertible into a ſoluble emetic tartar, perfectly neutral; for which purpoſe, nothing more is required than to boil it, and ſaturate it with cream of tartar, and to treat it in the manner above directed for the preparation of emetic tartar with glaſs of antimony. We may eaſily perceive that powder of Algaroth thus prepared is a calx of antimony conſtantly of the ſame degree of emetic ſtrength. It is emetic, becauſe the regulus of antimony firſt diſſolved by marine acid, and afterwards ſeparated from that acid, retains the quantity of phlogiſton that is neceſſary to give an emetic quality to the calx of antimony: but the quantity of phlogiſton which it retains, and therefore its emetic power, muſt always be the ſame: for the marine acid of the corroſive ſublimate, which afterwards becomes the acid of the butter of antimony, is always the ſame in quantity, and in its degree of concentration and of activity: conſequently the calx of antimony ſeparated from it muſt always contain an equal quantity of phlogiſton; and is therefore much preferable to glaſs of antimony, which contains ſometimes more and ſometimes leſs phlogiſton.

By ſubſtituting therefore powder of Algaroth to glaſs of antimony, and by treating it in the manner above-mentioned, we may obtain the moſt uniform and certain emetic tartar that can be prepared: phyſicians, who muſt be ſenſible of the advantage of ſuch a remedy, need not be anxious concerning its degree of ſtrength. If it were once known, they would have occaſion only to attend to the ſenſibility or irritability of the conſtitutions of their patients. *See the articles* ANTIMONY, POWDER *of* ALGAROTH, GLASS *of* ANTIMONY, *and alſo all the other preparations of antimony.*

DCLXXX. TARTAR (VITRIOLATED). Vitriolated tartar is a neutral ſalt compoſed of vitriolic acid ſaturated with the fixed alkali of tartar, or with any other very pure vegetable fixed alkali.

This ſalt is prepared by pouring vitriolic acid into a ſolution of vegetable alkali, till no more efferveſcence appears, or till the liquor becomes perfectly neutral, which may be known by the ordinary trial of ſyrup of violets. From this liquor, filtrated and evaporated, ſmall cryſtalls are obtained, each of which has many ſides, ſometimes more and ſometimes fewer; for the cryſtallization of this ſalt varies much in this reſpect. It is, in general, one of thoſe ſalts, the form of whoſe cryſtals is the leaſt conſtant. The greateſt number of the cryſtals of this ſalt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the ſalts which cryſtallize better by evaporation than by cold. It requires a large quantity of water to diſſolve it. According to Mr. Spielman's experiments, thirty grains only of this ſalt are ſoluble in an ounce of water with a heat marked by ten degrees above 0 in the ſcale of Mr. Reaumur's thermometer. Its taſte is moderately ſaline, and ſomewhat diſagreeable, but not acrid nor ſharp. It decrepitates, when heated ſuddenly and ſtrongly. It contains a ſmall quantity only of the water of cryſtallization, by means of which it cannot be liquefied; neither can it be fuſed but by a very intenſe heat.

As vitriolic acid has a greater affinity with the fixed alkaline baſis of the vitriolated tartar than with any other ſubſtance, excepting phlogiſton, and as this alkali has a ſtronger affinity with this than with any other acids, hence vitriolated tartar cannot be decompoſed but by means of the inflammable principle, as in the proceſs for making artificial ſulphur. Mr. Beaumé has indeed diſcovered that vitriolated tartar may be decompoſed in the humid way, by nitrous acid alone, which diſengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumſtances of this phenomenon, we ſhall find that this is no exception to the general rules concerning affinities, and that phlogiſton is the principal agent in this ſingular decompoſition, as Mr. Beaume has ſhewn in the explication that he has given of it. (d)

(d) Vitriolated tartar may be decompoſed by nitrous acid in the following manner, according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into

Vitriolated tartar may alſo be decompoſed by means of a double affinity when it is mixed with ſolutions of certain metals in acids. But as by phlogiſton only metals are diſſolved in acids, we need not doubt that this principle has alſo ſome influence in theſe decompoſitions.

Since vitriolic acid has a greater affinity than any other acid with fixed alkali, we may therefore make vitriolated tartar by applying that acid to any neutral ſalt compoſed of an acid and a fixed alkali, as in the decompoſition of nitre; and ſince fixed alkali has a greater affinity with vitriolic acid than any other ſubſtance, vitriolated tartar may be therefore made by applying a fixed alkali to any vitriolic neutral ſalt, the baſis of which is not fixed alkali. Accordingly, all vitriolic ſalts with baſes of volatile alkali, of calcareous, argillaceous, or metallic earths, may be decompoſed by fixed alkalis; and the compound formed by theſe decompoſitions will always be a vitriolated tartar, conſiſting of the fixed alkali employed in the operation, and of the vitriolic acid of the decompoſed neutral ſalt. Hence we may perceive, that vitriolated tartar is made in many chemical operations.

Before the theory of theſe operations was underſtood, and before the fixed vegetable alkali was known to be the ſame from whatever vegetable it was obtained, the ſeveral vitriolated tartars formed in different operations, and with the fixed alkalis obtained from different vegetables, were believed to be different kinds of ſalts, and were diſtinguiſhed by different names; as the *ſal de duobus*, *ſal polychreſt of Glaſer*, *arcanum duplicatum*. But we now conſider all theſe ſalts as the ſame vitriolated tartar, with which the other names are ſynonimous.

This ſalt is not of any uſe in the arts, and is but little uſed in chemiſtry. It is principally employed in medicine. Like the other neutral ſalts with baſes of fixed alkali, it is aperitive in ſmall doſes, as a gros [72 grains]; and it is laxative, when taken from ſix gros to twelve. The vitriolated tartar which is prepared by decompoſing nitre with vitriolic acid, called *ſal de duobus*, has been much celebrated as a remedy againſt the effects proceeding from an extravaſation of a milky humor, for which diſeaſe it has been conſidered as the beſt reſolvent and evacuant. Nevertheleſs, as Mr. Baron well obſerves in his Notes on Lemery, no reaſon can be given for preferring this ſalt to other neutral ſalts. On the contrary, as it is one of thoſe which are moſt perfectly ſaturated, its action and qualities muſt be leſs effectual than moſt of theſe. *See the articles* ACID (VITRIOLIC); ALKALI (FIXED VEGETABLE); CRYSTALLIZATION; *and* SALT.

DCLXXXI. TERRA FOLIATA TARTARI; FOLIATED EARTH *of* TARTAR. This name has been given improperly, and merely for

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a matraſs, and heated till the ſalt be diſſolved. From the liquor, when cold, true cryſtals of nitre may be obtained. Mr. Beaumé believes that this decompoſition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiſton, which, he ſuppoſes, enters into the compoſition of the vitriolated tartar: and he thinks that the reaſon why this decompoſition does not happen in the dry way or by fuſion, as well as in the humid way or by cold ſolution, is, that the nitrous acid is in the former caſe diſſipated by the action of the fire. This ſingular fact, which ſeems to contradict a general opinion, namely, that vitriolic acid is more diſpoſed than nitrous acid to unite with fixed alkali, is alſo confirmed by the intelligent and accurate Mr. Margraaf, who further affirms, that in the ſame manner of treatment, vitriolated tartar, Glauber's ſalt, and nitre, may be decompoſed by marine acid. As marine acid is certainly not more diſpoſed to unite with phlogiſton than nitrous and vitriolic acids are, Mr. Beaumé's explanation of this ſingular decompoſition does not ſeem to be ſatisfactory.

the ſalt of ſome earthy appearance, to a *neutral acetous ſalt with baſis of vegetable fixed alkali*, or to a combination of the acid of vinegar, ſaturated with the alkali of tartar or of other vegetable matters. This ſalt has alſo been called *regenerated tartar*, altho' it really be very different from true tartar, but only becauſe the alkali of tartar is united with an acid, which in ſome reſpects is ſimilar to the acid of tartar, but in others is very different, as may be ſeen at the articles TARTAR *and* VINEGAR.

The terra foliata is made, according to moſt diſpenſatories, by pouring upon a quantity of alkaline ſalt of tartar, in a glaſs-cucurbit, a ſufficient quantity of good diſtilled vinegar, at different times, to ſaturate all the alkali, or even a little more than is neceſſary for that purpoſe, and till the effervescence entirely ceaſes. This ſaturated liquor is to be filtrated, and evaporated to dryneſs, with a gentle heat. The dry ſalt thus obtained is to be diſſolved in ſpirit of wine, and the ſolution is to be again evaporated to dryneſs; by which means a ſalt is obtained more or leſs white, of a ſilky appearance, and compoſed of ſmall ſcales or leaves, from which it has been called *foliated*. When the ſalt is dried, and while it is yet hot, it muſt be ſhut up in a well cloſed bottle, becauſe it quickly becomes moiſt by expoſure to air.

When diſtilled vinegar is poured upon ſalt of tartar, little or no effervеſcence is made at firſt; but afterwards, when more vinegar is added, the effervеſcence becomes ſo conſiderable, that ſome of the liquor will flow over the veſſel, if care be not taken. This effervеſcence is produced by a large quantity of air that is diſengaged during the ſaturation. Accordingly the vapor extricated during the effervеſcence is very *aerial*, and ſo pungent, that if it be confined ſome time in a cloſe veſſel, and then ſet at liberty, it is as irritating and ſuffocating as volatile alkali, or volatile ſulphureous acid, although it be really different from either of theſe: for this vapor is nothing but aerial water ſimilar to the *gas* of ſpirituous mineral waters. (*e*)

When the ſaturation is advanced to a certain degree, the effervеſcence diminiſhes, and even ceaſes entirely, although the ſaturation be not yet compleated; the reaſon of which is, that the laſt portions of acid and of alkali do not very readily combine. The combination may be facilitated by frequently agitating the liquor, by which means the effervеſcence may be again renewed. When the liquor cannot by agitation be made to effervеſce more, it may be then allowed to ſtand during ſome time, as Mr. Beaume practiſes. This chemiſt, and very excellent obſerver, has remarked, that the mixture depoſites a certain quantity of earthy matter proceeding from the fixed alkali, and which muſt be neceſſarily ſeparated by filtration, to obtain a very white foliated earth of tartar. He has

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(*e*) The vapor which cauſes the effervеſcence in the preparation of this ſalt is the fixable air that is diſengaged from all mild alkaline ſubſtances by means of any acid; and the humid part of this vapor is nothing more than ſome particles of the effervеſcing liquor, which are forcibly thrown upwards by the riſing air, and which form a ſmall jet or ſhower above the ſurface of the effervеſcing liquor. *See* AIR (FIXABLE). The reaſon that this effervеſcence does not begin immediately upon pouring on the vinegar, is, that a part of the alkaline ſalt employed is generally cauſtic, or deprived of its fixable air, which part unites with the acid preferably to the mild part of the alkali, and abſorbs any air that is extricated from this latter part: and therefore till all the cauſtic part of the alkali be nearly ſaturated, little or no effervеſcence can happen.

alſo obſerved, that when the alkali employed is very pure, and free from any mixture of neutral ſalts, the ſaline matter produced by the proceſs has no foliated or cryſtallized appearance.

We have already remarked, that foliated earth of tartar is a deliqueſcent ſalt. This quality proceeds from the weakneſs of the union of the acid with the alkali; the cauſe of which ſlight union is, that ſome oily and ſpirituous principles are united with the acid in vinegar. The taſte of the foliated earth is ſharp, pungent, almoſt a little cauſtic, and partaking at the ſame time of the taſte of vinegar and that of fixed alkali. This ſalt is one of thoſe that are ſoluble in ſpirit of wine. It may be decompoſed merely by the action of fire; and from it, as from any other acetous ſalt, may be obtained by diſtillation, a radical vinegar, very penetrating and very concentrated.

Foliated earth of tartar is little uſed, but in medicine. It is conſidered as a powerful reſolvent and aperitive; and it probably poſſeſſes theſe qualities, merely as it retains ſome of the action of the acid and of the alkali, of which it is compoſed. Its doſe is from fifteen or twenty to thirty-ſix grains, or even more, when no irritation is apprehended. *See the articles* ALKALI (FIXED); SALT; SALTS (NEUTRAL); *and* VINEGAR.

DCLXXXII. TERRA JAPONICA. *See* JAPONIC EARTH.

DCLXXXIII. TEST, *and* TESTING. (*f*)

DCLXXXIV. TIN. Tin is a metal, the color of which reſembles that of ſilver, but is darker and leſs white. It is ſofter, leſs elaſtic, and leſs ſonorous than any other metal, excepting lead.

When it is bent backwards and forwards, it occaſions a crackling ſound, as if it was torn aſunder.

Tin has, like other imperfect metals, a ſmell and a taſte.

It is much leſs ductile than ſome harder metals; although it may be beat into very thin leaves.

The tenacity of the parts of tin is not very conſiderable, ſince a wire of this metal, the diameter of which is $\frac{1}{10}$ of an inch, can ſupport a weight of $49\frac{1}{2}$ pounds only.

It is the lighteſt of all metals, as it loſes only $\frac{1}{7}$th part of its weight, when immerſed in water. It is very fuſible, and requires for this purpoſe a heat much leſs than is ſufficient to make it red-hot.

With the heat neceſſary for its fuſion it may alſo be calcined, or at leaſt deprived of ſo much of its phlogiſton that it appears in form of a grey calx, which cannot be reduced entirely to tin without the addition of ſome inflammable matter.

Workmen call this imperfect calx of tin, *aſhes of tin*; and thoſe who travel in the country, caſting tin ſpoons, call it *droſs of tin*. This they carefully ſkim off, pretending thereby to purify their tin. But they preſerve this pretended droſs, and reduce it to tin by melting it with ſome pitch.

Theſe aſhes of tin, like other calxes of metals, may be further deprived of phlogiſton, by a calcination continued with a more intenſe fire, by which means

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(*f*) TEST *and* TESTING. A teſt is a large kind of cupel uſed in operations for refining large quantities of gold and ſilver by means of lead; and the operation is called *teſting*. *See* CUPEL; CUPELLATION, *and* REFINING.

it becomes more and more white, hard and refractory. It is then called *putty*, and is uſed in the arts for poliſhing glaſs and other hard bodies.

Calx of tin, very white and well calcined, is a very refractory ſubſtance. Its beautiful whiteneſs and refractory quality render it capable of forming, together with ſome fuſible and vitrifiable matters, a white enamel, which is uſed as a white glazing or covering for delf-ware. *See* DELF-WARE.

The moſt ordinary method of preparing this putty, is by mixing together lead and tin, and expoſing this mixture to a ſtrong heat. Theſe two metals have been found to be more eaſily calcinable when mixed than when ſingle. By adding to the calx thus obtained ſome ſand and vitrifiable ſalts, and by fuſing the mixture, a very beautiful white enamel may be made: for lead does not, like tin, loſe its fuſible quality by calcination.

I have expoſed very pure tin, ſingly, to a fire as ſtrong as that of a glaſs-houſe, during two hours, under a muffle, in an uncovered teſt; and having then examined it, I found it covered with an exceedingly white calx, which appeared to have formed a vegetation; and under this matter, a reddiſh calx, and a tranſparent hyacinthine glaſs; and laſtly, at the bottom, a piece of tin unaltered. This experiment was ſeveral times repeated with the ſame ſucceſs.

Nitre mixed with tin may be inflamed, and it haſtens conſiderably the calcination of this, as it does of other imperfect metals. The vapors which riſe during the ſeveral calcinations of this metal have generally an alliaceous or arſenical ſmell; becauſe tin generally contains ſome arſenic, as Mr. Margraaf has obſerved.

Although tin be one of the moſt calcinable metals by means of fire, it is much leſs apt to ruſt by the combined action of air and water, than iron and copper. Its ſurface, when it is clean and ſhining, loſes indeed its luſtre, and tarniſhes quickly by expoſure to air, but the ſlight kind of ruſt which is there formed remains thin and ſuperficial, and does not advance ſo deeply into the ſubſtance of the metal as the ruſt of iron and of copper generally does. Hence tin is advantageouſly employed to cover many utenſils made of theſe metals. *See* TINNING.

Every acid is capable of attacking or diſſolving tin.

Vitriolic acid requires to be aſſiſted by a certain degree of heat to diſſolve tin efficaciouſly. I have obſerved, that during this ſolution ſulphureous vapors are raiſed; and I have even ſeparated ſome black particles, which I have found to be true inflammable ſulphur. The production or extraction of this ſulphur requires a particular examination. *See* SULPHUR.

Nitrous acid attacks tin with very great violence, eſpecially when the metal is much divided. But when the acid is very pure, it rather corrodes and calcines than diſſolves tin. As the phlogiſton of this metal is not very ſtrictly engaged, the nitrous acid chiefly attacks it by means of this principle, which it ſeizes, and ſeparates from the tin, that is thus reduced to an unſoluble white earth, or calx, depoſited at the bottom of the acid. This calx of tin made by nitrous acid appears to be as perfectly dephlogiſticated, as that which had been expoſed during a long time to fire. I have attempted unſucceſsfully to reduce it to its metallic ſtate. This calx makes a very good white enamel.

The acid of common ſalt diſſolves tin perfectly well by help of heat. I have obſerved, that when I put a conſiderable quantity of fine granulated tin into a matraſs, and poured ſome ſmoking, and conſequently colored, ſpirit of ſalt upon it, that the acid quickly ceaſed to ſmoke, and loſt its color; that it attacked the tin with a ſenſible but moderate efferveſcence, and became ſaturated with it. This acid diſſolved more than half its weight of tin. The vapors which roſe during the ſolution had a diſagreeable arſenical ſmell; and the ſolution when ſaturated was clear and colorleſs as water. Having kept the ſolution in a bottle, I obſerved that, during the winter, it almoſt all cryſtallized, and that the cryſtals became fluid during ſummer. Some years afterwards a white ſediment was formed in this ſolution.

Tin has a greater affinity with marine acid than ſome other metallic ſubſtances which have alſo much affinity with this acid; for it ſeparates the marine acid from luna cornea, from corroſive ſublimate, and from butter of antimony. When tin is mixed, eſpecially with corroſive ſublimate, it decompoſes this ſalt, even without heat; and the mixture produced becomes moiſt by expoſure to air. If it be diſtilled before it has imbibed much moiſture, a very ſmoking ſpirit of ſalt, called *ſmoking ſpirit of Libavius*, is obtained. *See* Spirit (Smoking) *of* Libavius.

This acid retains much tin diſſolved, ſome of which it raiſes along with it in diſtillation, as it does ſeveral other metallic matters. Accordingly, in this diſtillation, a concrete, ſaline, metallic matter is ſublimed, that may be called *butter of tin*: which name has been given by ſome chemiſts to the ſmoking ſpirit.

From the detail we have given of the ſolutions of tin by nitrous and marine acids we may perceive, that the former acid deprives it of all its inflammable principle, but has no action upon its dephlogiſticated earth; and that the effects of the marine acid upon this metal are quite the reverſe. Accordingly, when theſe two acids are united together, forming an aqua regia, they compoſe a menſtruum, which acts very efficaciouſly upon tin, on account of the activity of the nitrous acid, but which does not deſtroy the metal, as nitrous acid ſingly does, becauſe the action of this acid is moderated by the marine acid: hence, the more nitrous acid is contained in aqua regia, the more ſimilar are its effects upon tin to thoſe produced by nitrous acid alone; and reciprocally with regard to marine acid.

A good ſolution may be made of tin in aqua regia, if attention be given to the following particulars. A ſmall quantity only of tin ought to be put into the acid, and no more added till the firſt piece be entirely diſſolved; becauſe when much tin is added at once, the heat occaſioned by the ſolution encreaſes the activity of the ſolvent ſo much, that the tin is as much calcined and precipitated as if pure nitrous acid had been employed; but when the tin is added gradually, and the heat is thus reſtrained, the aqua regia may be ſo charged with this metal, that it ſhall be thick and viſcid, like a a liquid tranſparent reſin. The ſolution thus charged has a yellow-reddiſh color.

We may obſerve, that in this ſolution there is a conſiderable quantity of tin upon which the nitrous acid of the aqua regia has not exhauſted all its action, although this menſtruum ſeems to be more than ſaturated; for I have obſerved, that when this liquor is heated, an efferveſcence happens entirely ſimilar to that which is occaſioned during the ſolution of metals by acids. This efferveſcence laſts till the parts of the tin which were only half diſſolved have been rediſſolved a second time; after which the ſolution is found to have loſt its color. Sometimes this ſolution becomes quite fixed or ſolid when it cools, and appears like a firm jelly, and tranſparent as cryſtal.

All the ſolutions of tin are acid and corroſive; and may be decompoſed by being diluted with much water; in which caſe, the tin is copiouſly precipitated in form of a white calx.

When a ſolution of tin is mixed with a ſaturated ſolution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Caſſius. See that word.* This powder is employed for painting on enamels and on porcelain.

The ſolution of tin in aqua regia, added to the tinctures of cochineal, of gum lac, and of ſome other red tinctures, heightens the color of theſe, and changes it from a crimſon or purple to a vivid reddiſh-yellow or fire-colored ſcarlet. Dyers call this ſolution of tin, with which they give a ſcarlet tinge, *the compoſition.* We may obſerve, that this color ſucceeds only with wool and other animal matters. Attempts have been made, but without ſucceſs, to give this color to thread, to cotton, or even to ſilk, although this latter ſubſtance has many properties of animal matters.

I have alſo obſerved, that the larger quantity of nitrous acid is contained in the aqua regia, which diſſolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow; ſo that the ſolution of tin made with marine acid alone, or with vitriolic acid, do only give to red tinctures a crimſon color, as alum does. *See* Dying.

Vegetable acids, as vinegar and cream of tartar, are alſo capable of diſſolving tin: but the properties of theſe ſolutions have not yet been well examined.

Tin, according to Mr. Geoffroy's table of affinities, has a ſtronger affinity with the acid of common ſalt than regulus of antimony, copper, ſilver, and mercury; becauſe the combinations of this acid with theſe metals are decompoſed by tin, which precipitates them; and unites with the acid.

Sulphur may be united with tin by fuſion, and forms with it a brittle maſs, more difficultly fuſible than pure tin. Sulphur has in this reſpect the ſame effect upon tin as upon lead. The allay of ſulphur leſſens the fuſibility of theſe very fuſible metals, while it encreaſes the fuſibility of other difficultly fuſible metals, as of iron and copper.

Tin may be allayed with all metals by fuſion, and in all proportions; but it abſolutely deſtroys their ductility. A remarkable circumſtance is, that the moſt ductile metals, as gold and ſilver, are thoſe the ductility of which is moſt injured by tin. The vapor of a ſingle grain of tin is capable of rendering a conſiderable quantity of gold brittle. The ductility of copper is leſs injured by tin than that of other metals, although it is conſiderably injured. A ſingular circumſtance concerning this allay is, that tin, although a very ſoft metal, and not at all ſonorous, augments conſiderably the ſtiffneſs, the hardneſs, and the ſonorouſneſs of copper, as we ſee in *bell-metal.*

The allay, or amalgam of tin with mercury, is employed to cover one of the ſurfaces of looking-glaſſes, by which they are rendered capable of reflecting the rays of light, and of forming mirrors. This covering of tin and mercury, which is applied upon glaſſes, is called *tinning*.

Tin, allayed with an equal quantity of lead, forms the ſolder uſed by plumbers.

According to Mr. Gellert's table, the affinities of tin are, iron, copper, ſilver, and gold. *See, for the allays of tin, the words* ALLAY, AMALGAM, *and* BRONZE.

Tin is not much uſed in medicine, and for good reaſons: for we find, from a long Diſſertation by Mr. Margraaf upon this metal, that tin generally contains more or leſs of an arſenical matter, which probably proceeds from the ores of tin, as all theſe contain arſenic. *See* ORES, *and* SMELTING *of* ORES. Mr. Margraaf diſcovered this arſenical part of tin chiefly in the humid way, and by ſolution in acids. The white calx of this metal is commonly employed in the preparation of the *antihectic of Poterius*, and of the *lilly of Paracelſus*: but this calx is unſoluble and ineffectual; beſides, it appears to furniſh no part of the lilly.

Tin is very extenſively uſeful in many arts, as we may judge from what has been ſaid of the different preparations of this metal.

DCLXXXV. TINNING *of* COPPER, *and of* IRON.

Tinning is an operation by which a very thin layer of tin is applied to the ſurface of ſome metals, and eſpecially of copper and of iron. The methods of tinning theſe two metals are different. Copper is tinned after it has been formed into utenſils, and by the copper-ſmiths who form theſe utenſils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in ſome other places. Workmen, called *tin-ſmiths*, do only form theſe plates, which are brought ready made from their proper manufactories, into the various utenſils required.

The ſeveral operations for tinning of copper and iron are founded, firſt, on the facility with which tin unites with theſe metals, which is ſo great, that when either of theſe metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheleſs, the tin incorporates with theſe metals, diſſolves in ſome meaſure their ſurface, and forms a kind of allay, at leaſt when the tinning is well performed.

Secondly, the foundation of all the parts of the operation uſed to make the tinning ſucceed is, that metals cannot pe[illegible]rate with each other but when they are in a metallic ſtate, and that they cannot unite with any earthy matter, not even with their own earths or calxes.

Hence, the whole art of tinning conſiſts in applying melted tin, the ſurface of which ſhall be very clean, metallic, and not covered with any aſhes or calx of tin, to the ſurface of iron or of copper, which muſt alſo be very clean, and free from all ruſt or calx.

To attain theſe purpoſes, the following method is uſed. As the ſurface of copper is continually altered merely by the action of air, the workmen, before the tinning of any veſſel, ſcrape its ſurface with a ſteel inſtrument till it be clean and bright: then they place the veſſel upon kindled coals, and heat it to a certain degree: as ſoon as it is hot, they rub it with pitch; and then apply the melted tin, which they ſpread upon the ſurface of the copper by means of hards. Pure tin is ſeldom uſed for this purpoſe; but generally two parts of tin are allayed with one part of lead.

The pitch uſed in this operation is quite neceſſary, becauſe the degree of heat given to the copper is ſufficient to calcine its ſurface in ſome meaſure; and this alteration, however ſlight, would prevent the perfect adheſion of the tin, unleſs, by means of the pitch, the phlogiſton was reſtored to it at the very inſtant of the application of the tin. This pitch prevents alſo the ſlight calcination which would happen on the ſurface of the tin, or revives the ſmall particles of calx which are formed during the operation.

When plates of iron are to be tinned, they muſt be perfectly well cleanſed, which is done by ſcouring them with ſand, and ſteeping them ſome time in acid liquors: then they are to be wiped, and dried quickly and perfectly. Laſtly, they are to be plunged vertically into a veſſel containing melted tin, the ſurface of which is covered with fat and pitch. Theſe fat ſubſtances covering the ſurface of the tin, ſupply it continually with phlogiſton, prevent its calcination, by which its adheſion to the iron would be impeded, and alſo render the ſurface of the iron, while it paſſes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is alſo uſed ſucceſsfully in the tinning of iron and of copper, and always for the ſame reaſon. The acid of this ſalt perfectly cleans the ſurface of the metals to be tinned, and alſo the oily matter contained in ſal ammoniac furniſhes the phlogiſton that is neceſſary in this operation. Thus, by heating theſe metals to a certain degree, and rubbing them with ſal ammoniac, the tin may be applied immediately afterwards.

The advantages received from tinning are very conſiderable. As tin is a ſoft and fuſible metal, veſſels formed of it alone would not have ſufficient ſtrength and hardneſs to keep their ſhape in common uſe, and would alſo be liable to be melted with a ſmall heat: but when it is applied to the ſurface of hard and difficultly fuſible metals, as copper and iron, many veſſels may be fabricated, which have the advantage of being preſerved, by means of the tin, from ruſt, to which the copper and iron are very ſubject. It has been, nevertheleſs, juſtly alledged, that copper veſſels are not perfectly prevented from ruſt or verdigriſe by tinning; and this fault is ſo much more important, as tinned copper veſſels are generally uſed for the preparation of victuals. Theſe veſſels therefore, even when tinned, ought not to be employed for this purpoſe; eſpecially as tin itſelf is ſuſpected of being hurtful to health, ſince Mr. Margraaf diſcovered that arſenic is contained in almoſt all tin; and alſo becauſe lead, a moſt hurtful metal, is uſed in tinning. Nevertheleſs, tinned copper veſſels may be uſed for many other purpoſes. Beſides, the tinning of copper and iron veſſels may be improved, by attending to the fundamental principles of this art delivered in the preſent article.

DCLXXXVI. TINNING *of* LOOKING-GLASSES. This operation conſiſts in applying an amalgam of tin and mercury upon one of the ſurfaces of looking-glaſſes, by which they are rendered much more capable of reflecting the rays of light, and conſequently of repreſenting, in a clear and lively manner, the images of objects.

This effect of the tinning of looking-glaſſes is founded on the ſuperior opacity, and conſequently on the ſuperior reflective power of metallic to all other ſubſtances.

Glaſſes to be tinned are placed upon tables, in a perfectly horizontal or level ſituation. The ſurface, previouſly well cleaned, is to be covered with tin-leaves, which alſo muſt be very clean. Upon theſe is poured a ſufficient quantity of mercury to cover the whole ſurface, and it is allowed to reſt ſome time, that it may amalgamate perfectly with the tin-leaves: then a ſmall degree of inclination is given to the glaſs, that the ſuperfluous mercury may run off; which inclination muſt be gradually encreaſed till the glaſs be at laſt brought to a vertical ſituation, by which means no more mercury remains than is really amalgamated with the tin. As the ſurface of the glaſs is exceedingly ſmooth and well poliſhed, the amalgam is in very perfect contact with it, and therefore firmly adheres to it.

The ſucceſs of this operation depends much on the cleanneſs of the ſurface of the glaſs; for the leaſt dirt or duſt interpoſed betwixt the amalgam and the ſurface of the glaſs would abſolutely prevent the adheſion of contact between theſe two bodies.

Since vitrified matters, as glaſſes are, cannot unite intimately with metallic ſubſtances, the adheſion of the amalgam upon the glaſſes is not ſo ſtrong as that of metals upon metals; as in the tinning of copper and of iron, in which there is a ſolution, a penetration, and an intimate union of the tin with the ſurface of the tinned metal: but in the tinning of looking-glaſſes, there is only the adheſion of contact, or of a perfect juxtapoſition, which may take place between any bodies, however heterogeneous, by the application of their poliſhed ſurfaces. Accordingly, this metallic covering may very eaſily be taken off, and ought to be preſerved from moiſture, and from any kind of rubbing, however ſlight. For which reaſon, the ſuperfluous mercury muſt be made to run off very gently and ſlowly, otherwiſe all the amalgam might fall off by its weight.

DCLXXXVII. TINCAL. (g)

DCLXXXVIII. TINCTURE. By this name are diſtinguiſhed, in chemiſtry and pharmacy, all ſpirituous liquors that are colored by being digeſted upon different ſubſtances. Theſe are, properly ſpeaking, infuſions in ardent ſpirits.

Many chemical preparations are called *tinctures*. We ſhall treat of ſome of the chief of theſe.

DCLXXXIX. TINCTURE (ALKALINE). *See* TINCTURE *of* SALT *of* TARTAR.

DCXC. TINCTURE *of* ANTIMONY. This tincture is made, according to the Paris Diſpenſatory, in the following manner: Let a mixture of one part of crude antimony with two parts of the alkafine ſalt of tartar, be fuſed in a covered crucible, and the fuſion continued during an hour. The melted matter is to be poured out; and as ſoon as it has become ſolid, it is to be pulverized: while yet hot, it is to be put into a matraſs; and upon this powder rectified ſpirit of wine is to be poured, to a height above the powder equal to the breadth of three fingers. This tincture is to be digeſted with a gentle heat during ſeveral days, by which it acquires a deep red color; and then it is to be decanted and preſerved in a well-cloſed bottle.

(g) TINCAL. Borax, in the crude ſtate in which it is brought from India, and before it is refined, is called tincal. It conſiſts of ſmall cryſtals, of a yellowiſh color, and it has a greaſy or unctuous touch. According to Mr. Cadet, it contains a larger quantity of the peculiar vitreſcible earth of borax, than the refined ſalt commonly ſold does. *See* BORAX, *and* SALT (SEDATIVE).

In this fuſion of crude antimony with fixed alkali, a liver of ſulphur is formed, which diſſolves the reguline part of antimony. It is conſequently an antimoniated liver of ſulphur, nearly of the ſame nature as that of which *kermes mineral* is made: but in the preſent operation this matter is not diſſolved in water, but is digeſted in ſpirit of wine; which menſtruum ſeems to diſſolve a part of the whole matter, that is, a part of the liver of ſulphur, and by means of it alſo ſome of the regulus of antimony; for this tincture acquires a red color, and produces nauſea, according to Lemery, when taken internally. According to the ſame author, the doſe of this tincture is from four drops to twenty, and is to be adminiſtered in ſome proper liquor.

The medicinal effects of this preparation may be very good, and analogous to thoſe of kermes; but it is not much uſed. *See* KERMES (MINERAL).

This ſolubility of antimoniated liver of ſulphur in ſpirit of wine is remarkable: but an explanation of all the appearances that occur in this and in ſeveral other operations, would require more particular reſearches than have yet been made.

DCXCI. TINCTURE *of* MARS. Iron, being a metal much employed in medicine, has been prepared in various manners for internal uſe. Amongſt the principal of theſe are the following tinctures.

DCXCII. TINCTURE *of* MARS (LUDOVICUS'S). This tincture is made, according to the Paris Diſpenſatory, in the following manner: Four ounces of martial vitriol calcined to whiteneſs are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the conſiſtence of honey. This maſs is to be put into a matraſs, into which ſome rectified ſpirit of wine is to be poured to a height equal to the breadth of four fingers. After a digeſtion during ſome time in a ſand-bath, the tincture is to be decanted, and freſh ſpirit of wine is to be poured on the reſiduum, and digeſted as before. Theſe operations are to be continued as long as the ſpirit of wine acquires color: and, laſtly, all theſe tinctures are to be mixed together and preſerved for uſe.

The theory of this proceſs is not well known; becauſe all the circumſtances have not been examined with ſufficient attention. We ſee, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very ſtrongly to the vitriolic acid, or which is even quite diſengaged from that acid by calcination; and that this combination of iron with cream of tartar may be ſoluble in ſpirit of wine, to which it may communicate color, and conſequently may form the preſent tincture: but does not the cream of tartar act alſo upon the iron which is united with the vitriolic acid; and if it does not act, does the martial vitriol diſſolve in ſpirit of wine?

If it does not diſſolve in this ſpirit, when it is ſingle and in its ordinary ſtate, and charged with much iron, may it not become ſoluble either when it has depoſited a part of its iron, or by means of the acid of tartar? Theſe are queſtions which, I believe, have not been yet examined; but which muſt be aſcertained, before we can know preciſely the nature of this tincture of Mars. For its medicinal virtues, *ſee the article* IRON.

DCXCI. TINCTURE *of* MARS *of* MYNSICHT. This tincture is made by digeſting the martial flowers of ſal ammoniac with a ſufficient quantity of rectified ſpirit of wine in a matraſs.

Spirit of wine diſſolves the ſalt formed by the union of iron with the acid of ſal ammoniac; but as this ſpirit can alſo diſſolve the ſal ammoniac itſelf, it may be charged with a certain quantity of the latter ſalt in this operation: it is even very poſſible, that by means of this ſal ammoniac, it diſſolves a greater quantity of the martial ſalt than it would otherwiſe do; and reciprocally, that the martial ſalt puts it in a condition of diſſolving a greater quantity of ſal ammoniac; which effects are ſimilar to thoſe produced by treating in the ſame manner corroſive ſublimate and ſal ammoniac in ſpirit of wine: but I do not believe that any reſearches have been made to elucidate this ſubject. Chemiſts, who have given receipts for moſt of the medicinal preparations of the kind of which we now treat, made frequently capricious mixtures, the effects of which they did not know. Theſe preparations have been conſecrated by uſe, although little trouble has been taken to aſcertain their nature: but now that chemiſtry, taken in its true and genuine ſpirit, has become a ſcience as accurate and rigorous in ſome meaſure as geometry, all theſe ancient receipts ought to be ſcrupulouſly examined. We ſhould then certainly reject many of theſe for their unfitneſs to produce the effects expected, and we ſhould know better the virtues of thoſe which ſhould be judged worthy to be retained in uſe. Probably the tincture of Mars of Mynſicht poſſeſſes the medicinal qualities of iron diſſolved by marine acid, and of ſal ammoniac.

DCXCIII. TINCTURE *of* MARS (ALKALINE) *of* STAHL. This preparation, the knowledge of which Stahl has communicated to us, is a ſolution of iron in fixed alkali. Although this ſaline ſubſtance be capable of acting directly upon iron, and of diſſolving it in ſome meaſure, this combination ſucceeds much better when the iron to be united with the alkali is previouſly divided by being diſſolved in an acid, and eſpecially in nitrous acid, as Stahl has ſhewn.

According to the proceſs of this celebrated chemiſt, the iron ought to be previouſly diſſolved in nitrous acid, and the ſolution ought to be as perfectly ſaturated as poſſible. This ſaturated ſolution is to be added at ſeveral different times to a ſtrong ſolution of vegetable fixed alkali. Each time that the ſolution of iron is poured into the alkaline liquor, a kind of precipitate or coagulum of a deep red ſaffron color is inſtantly formed: but this precipitate diſappears ſoon after, and diſſolves entirely in the alkaline liquor, to which it communicates a deep-red yellowiſh color. More of the ſolution of iron is to be poured into the alkaline liquor, till the precipitate is no longer rediſſolved. Laſtly, this ſolution, which is the martial alkaline tincture of Stahl, is to be filtrated.

We may eaſily conceive what paſſes in this proceſs. The alkali, into which the combination of iron with nitrous acid is poured, decompoſes at firſt this combination, by uniting with the acid, and precipitating the iron. But as there is much more alkali than is required to ſaturate the quantity of acid added, the uncombined portion of alkali finding the iron in a very divided ſtate, attacks and diſſolves it perfectly.

Iron is not the only metal that may be thus diſſolved by an alkali. Almoſt every metal is more or leſs ſoluble by alkalis, as Mr. Margraaf has ſhewn. *See his Opuſcules Chymiques, Diſſ.* III. This celebrated chemiſt found that not very pure alkalis but alkalis phlogiſticated by calcination with ox's blood and volatile alkali, were fit for this purpoſe.

This ſolution of iron in fixed alkali does not always ſucceed, and even ſometimes fails, when all the circumſtances directed by Stahl have been obſerved. I have remarked, and alſo Mr. Beaumé, that it ſucceeds much more conſtantly, and almoſt certainly, when a ſolution of iron not nearly ſaturated and very acid is employed; and when the ſolution has not the reddiſh-yellow color of ruſt that ſaturated ſolutions have, but is clear and limpid, or only ſlightly greeniſh. We were alſo induced to believe, that a ſimilar exceſs of acid was favorable for rediſſolving other metallic precipitates from their acid menſtruums by means of alkali; and even that without this exceſs, the operation cannot ſucceed. But Mr. Marges, an intelligent chemiſt, has ſhewn me a ſolution of iron much impregnated, and high-colored, the iron of which might be perfectly diſſolved by fixed alkali, without heat; and which conſtantly formed the martial alkaline tincture, either by pouring the ſolution to the alkali, or the alkali to the ſolution; which proves that this phenomenon depends on the concurrence of ſeveral circumſtances; as on the ſtate of the iron in the nitrous acid, which is known to be very variable; on the greater or leſs phlogiſtication of the alkali; and perhaps alſo on ſeveral other circumſtances, which ought to be more fully examined, before we can form a judgment.

The martial alkaline tincture certainly contains an iron very much divided, in a ſaline and perfectly diſſolved ſtate, though it is not united to any acid; and as it alſo poſſeſſes a ſaponaceous alkaline character, it may be very uſeful in all caſes where martial and anti acid remedies are at the ſame time indicated: and theſe caſes are very frequent, as practical phyſicians well know.

A very fine ſaffron of Mars may be ſeparated from this ſolution, either by precipitating the iron by gradually ſaturating the alkali with any acid, or by a ſpontaneous depoſition of a ferruginous ſediment, which is ſlowly formed in this, in the ſame manner as in the acid ſolutions of iron. We ſhall only obſerve, that the iron which has been thus diſſolved by an alkali is very ſoluble in acids; ſo that when it is to be precipitated by an acid, we muſt take care not to add a drop more than is neceſſary for the perfect ſaturation of the alkali, otherwiſe all the precipitate inſtantly diſappears, and the liquor becomes clear and almoſt colorleſs. *See* ALKALI *and* IRON.

DCXCIV. TINCTURE *of* MARS (TARTARISED). This preparation, like the preceding, is called a tincture, although it contains nothing ſpirituous, but merely from its deep color. It is a ſolution of iron by the acid of tartar; and is a true *Martial ſoluble tartar*, as we ſhall ſee.

This combination is made, according to the Paris diſpenſatory, in the following manner. Six ounces of clean filings of iron, and a pound of powdered white [illegible] are to be mixed together in an iron veſſel; the mixture is to be moiſtened with a ſufficient quantity of water to form it into a maſs, which muſt be left [illegible] during 24 hours, that the acid of tartar may begin to act upon the iron. Then ſix Paris pints [12 pounds] of pure water are poured on the mixture, and boiled together during two hours. From time to time the mixture muſt be ſtirred during the boiling, and hot water is added to ſupply the place of that which is evaporated. The liquor is then to be left to ſettle, and to be filtrated and evaporated to the conſiſtence of a liquid ſyrup. Laſtly, an ounce of ſpirit of wine is to be added to it, to prevent the ſolution from becoming mouldy.

In this operation, the acid of tartar diſſolves the iron, becomes ſaturated, and forms with it a neutral ſalt, which is not only very ſoluble in water, but which is even very deliqueſcent: hence this ſalt cannot be cryſtalliſed, but is obtained in the ſtate of a liquor, or of an extract. ſometimes dry and ſometimes ſoft, according as it has been more or leſs evaporated. The color of this ſalt is red, or brown, and its taſte is the ſame as that of all ſalts the baſes of which are iron, though ſomewhat leſs auſtere and ſtyptic.

The union of the acid of tartar with iron is very weak and very ſuperficial in this combination; and hence this ſalt is very deliqueſcent. This deliqueſcence is ſurprizing, conſidering that, as we have remarked elſewhere, the two ſubſtances which compoſe it have little or no ſolubility in water. From this difficult ſolubility in water of the component parts of the tartariſed tincture we may conclude, that in whatever proportions theſe parts are mixed together, this tincture muſt always be a neutral ſalt, perfectly or nearly ſaturated: for if any portion of tartar be not combined with the iron, it will remain at the bottom of the veſſels, or upon the filter; and the ſame obſervation may be applied to the iron that is not combined with the tartar. Nevertheleſs, as pure tartar is ſoluble in water, and as conſequently a ſmall portion of it may remain unſaturated in the liquor, it would be proper, if this martial ſoluble tartar be required perfectly neutral, to add more filings of iron than are ſufficient to ſaturate all the acid; becauſe the ſuperabundant quantity could not remain in the ſolution, and becauſe by this method of employing a large quantity of filings, the operation may be much ſhortened; whereas it would be very long, if no more filings were employed than is required for the ſaturation of the tartar, and if at the ſame time all the tartar was required to be ſaturated.

The tartariſed tincture of Mars has the ſame medicinal qualities as the other ſaline and ſoluble preparations of iron; but it is, as we have ſaid, the leaſt ſtyptic. Accordingly, in caſes where martial preparations are indicated, and at the ſame time the ſtyptic quality of iron is apprehended, this is one of the beſt preparations of iron that can be preſcribed. It does not eſſentially differ from the infuſion of martial balls. *See* IRON, *and* TARTAR.

DCXCV. TINCTURE *of* METALS, *or* LILLY *of* PARACELSUS. This preparation may be made by ſeveral proceſſes; but as they do not much differ, we ſhall here give the eaſieſt and readieſt.

Two parts of martial regulus of antimony, one part of fine tin, and one part of pure copper, are melted together in a crucible. The allay thus compounded

pounded is to be powdered, when cold, and mixed with thrice its weight of purified nitre. The mixture is to be thrown at different times into a red-hot crucible, where it detonates, and is expoſed to a violent fire, till the metals be perfectly reduced to calxes. The matter is to be taken from the crucible while red-hot, and immediately thrown into a heated iron mortar, where it is quickly powdered. The powder is to be put, while yet hot, into a matraſs, and upon it ſome rectified ſpirit of wine is to be poured to a height equal to the breadth of four fingers. The digeſtion is continued during ſome days, or till the ſpirit of wine has acquired a very deep yellowiſh red color. The ſpirit is to be decanted and kept in a bottle; and is called the *Tincture of Metals*, or *Lilis of Paracelſus*.

From this name *Tincture of Metals*, we find that the ſpirit of wine was ſuppoſed to extract ſomething from the metals on which it is digeſted in this proceſs; perhaps its color gave riſe to this opinion. Neverthelefs, as Mr. Baron well obſerves in his Notes on Lemery, if we conſider that the metallic matters are reduced almoſt to the ſtate of pure earths by calcination, we ſhall be convinced that no part of them can be diſſolved by the ſpirit of wine. Beſides, Mr. Beaumé, having particularly examined this preparation, was convinced by experiments that no metallic matter can be ſeparated from it. But although it contains no metallic matter, we do not ſay that it is ineffectual, or that it has no other qualities but thoſe of the pure ſpirit of wine. On the contrary, we know that the nitre is alkaliſed in this operation; and that this alkali, which is capable of being rendered as cauſtic by metallic calxes, as it is by quicklime, acquires a power of acting ſingularly and effectually on ſpirit of wine, which it partly decompoſes. This alkali either forms with the ſpirit of wine, or it ſeparates from this ſpirit, an oil, with which it combines, and to which it gives color, and a very acrid taſte. Hence the tincture of metals reſembles much the *tincture of ſalt of tartar*, of which we ſhall afterwards treat, and like which it has a ſpirituous, ſaponaceous, acrid, and alkaline character. Accordingly, it is ſucceſsfully uſed when the fibres and veſſels require to be excited and animated; as in apoplexies, palſies, dropſies. For the ſame reaſon, it is capable of accelerating the motion of the blood, and of encreaſing certain ſecretions and excretions, particularly ſweat and urine. The doſe of this tincture is from ſix or twelve drops to forty or even more, and it muſt be adminiſtered in ſome proper cordial.

DCXCVI. TINCTURE *of* GOLD. *See* GOLD (POTABLE).

DCXCVII. TINCTURE *of* SALT *of* TARTAR.

This tincture is made by pouring ſome rectified ſpirit of wine to a height equal to the breadth of three or four fingers, into a heated matraſs that contains ſome hot ſalt of tartar, which had been previouſly fuſed in a crucible and powdered. The matraſs is to be cloſed, and the digeſtion is to be continued during ſeveral days with a gentle heat, or till the ſpirit of wine has acquired a fine reddiſh yellow color.

This preparation is eſſentially the ſame as the tincture of metals, as in both theſe, the fixed alkali acts upon and colors the ſpirit of wine; with this difference only, that as the alkali of tartar, in its ordinary ſtate, is much leſs cauſtic than when it has been calcined with metallic calxes, it therefore acts leſs quickly and powerfully in the tincture of ſalt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of ſalt of tartar, an alkali previouſly rendered cauſtic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of theſe two tinctures are the ſame.

DCXCVIII. TINCTURES *of* VEGETABLE *and* ANIMAL SUBSTANCES. Many medicinal preparations are called tinctures, becauſe they are made by digeſting certain vegetable and animal ſubſtances in ſpirit of wine, to which they communicate different colors, according to their nature.

Some of theſe tinctures are made with one vegetable or animal ſubſtance only. Theſe are called *ſimple tinctures*, and they are diſtinguiſhed by the name of the vegetable or animal matter employed; ſuch are the tinctures of myrrh, of aloes, of ſaffron, of caſtor, and many others.

Others contain a greater or leſs number of different vegetable and animal ſubſtances, which are digeſted in ſpirit of wine, according to the ſeveral receipts. Theſe have the general name of *compound tinctures*, and are alſo diſtinguiſhed by the names of their particular authors and qualities.

We ſhall not here enter into a detail of theſe ſeveral tinctures, becauſe they are rather objects of pharmacy than of chemiſtry; but ſhall confine ourſelves to the following general obſervations.

Firſt, as vegetables and animals are compoſed of ſeveral principles which are not all ſoluble, or not equally ſoluble in ſpirit of wine, we cannot conſider ſpirituous tinctures as complete extracts of the vegetable and animal ſubſtances employed in their preparation.

Secondly, the principles of theſe ſubſtances upon which ſpirit of wine can act, are volatile eſſential oils, and others of the ſame nature; reſins, properly ſo called; any oils that are in a ſaponaceous ſtate, and ſoluble in water by means of ſome ſaline matter; acids; and laſtly, ſeveral kinds of neutral ſalts. And the principles which ſpirit of wine cannot diſſolve directly are ſweet oils and oily concretions that are not volatile nor ſaline; ſubſtances purely gelatinous and gummy; earthy matters not ſaline nor ſoluble in water; and laſtly, many neutral ſalts, which are inſoluble in ſpirit of wine, the v[illegible] kinds of which have not yet been determined.

Thirdly, many of the vegetable and animal principles that are eſſentially inſoluble in ſpirit of wine, particularly gums, jellies, and neutral ſalts, ſoluble in water.

Fourthly, from the laſt obſervation we may perceive, that tinctures drawn from the ſame vegetable or animal ſubſtance muſt differ conſiderably according to the ſtate of dryneſs of theſe ſubſtances, and the dephlegmation of the ſpirit of wine employed. For a tincture made from moiſt plants, and with a weak ſpirit of wine, muſt contain ſome gummy and ſaline principles, which could not be contained in a tincture made with the ſame plants perfectly dried, and a ſpirit of wine perfectly rectified.

Fifthly, as many chemical experiments ſhew that ſubſtances naturally unſoluble in any certain menſtruum, may be rendered ſoluble in that menſtruum by ſome other intermediate ſubſtance; and as, amongſt the vegetable and animal principles, ſome ſuch intermediate ſubſtances may exiſt; we cannot therefore affirm that ſpirituous tinctures contain no other of theſe principles but ſuch as are naturally ſoluble in ſpirit of wine; but we rather think that they probably do contain other principles. This ſubject has not been examined ſufficiently to enable us to ſpeak upon it in a leſs vague and general manner than we now do. *See* ANALYSIS *by* MENSTRUUMS, *and* SPIRIT (ARDENT).

DCXCIX. TIN-GLASS. This name is frequently given to the ſemi-metal biſmuth. *See* BISMUTH.

DCC. TOBACCO. (*h*)

DCCI. TOPAZ. (*i*)

DCCII. TORREFACTION. This name is given to a kind of calcination by which ores are deprived of the volatile mineraliſing ſubſtances, the ſulphur and arſenic which they contain. It is alſo applied to ſignify the roaſting of ſome pharmaceutical preparations. Thus, for inſtance, we ſay *torrefied rhubarb*, &c.

DCCIII. TRAGACANTH (GUM). *See* GUM.

DCCIV. TRIPOLI. (*k*)

DCCV. TRITURATION is an operation which conſiſts in the mechanical diviſion of bodies, and is executed by the ſame methods, and by the ſame inſtruments, that are employed for other diviſions of this kind; that is to ſay, in mortars, upon porphyries, and in mills. *See* DIVISION. This word is generally applied to denote the diviſion that is made of ſeveral bodies together, to unite them with each other; as, for inſtance, the extinction of mercury in the operation of ethiops mineral, and others ſimilar.

DCCVI. TURBITH MINERAL. This name is given to a preparation of mercury made in the following manner.

(*h*) TOBACCO. The leaves of this plant being diſtilled in a retort, without addition, yield an acrid, empyreumatic, poiſonous oil. Tobacco loſes its virulence by long coction in water. From an ounce of American tobacco, water extracted four drams and thirty grains; and from an ounce of the ſame tobacco, ſpirit of wine extracted one dram and thirty grains. The ſpirituous extract was ſtronger than the aqueous. The former had a fine green color; the latter was yellowiſh-brown. The diſtilled water and ſpirit of tobacco have no taſte or ſmell. *Neuman.*

(*i*) TOPAZ is a precious ſtone, of a golden color, the fourth in hardneſs from diamonds. Mr. Pott has made ſome curious experiments on the Saxon topaz. He found that this ſtone could not be fuſed with even eight times its weight of fixed alkali, but that it was vitrifiable by addition of half its weight of borax, or of thrice its weight of chalk. It was alſo fuſed by calxes of lead or of copper, and by fuſible ſpar, but not by nitre.

This ſtone may be imitated by fuſing a mixture of two ounces of powdered rock-cryſtal with ſeven ounces of red-lead.

(*k*) TRIPOLI is an earth conſiſting of very fine particles. It is uſed for poliſhing hard bodies. Tripoli is not fuſible in the fire. Its colors are various; grey, yellow, white. It becomes more hard and compact in the fire, as clay does; and from this property probably it has been conſidered as an argillaceous earth; tho' it does not appear to have been ſufficiently examined. It has been imagined to be a powder formed by the decompoſition or mouldering of jaſper. Neuman ſays, that by diſtilling two ounces of it, he obtained two ſcruples of a weak marine acid, and a ſmall portion of ſal ammoniac; that by diſtilling a mixture of this earth and nitre he obtained an aqua regia; and that of ſixty grains of Tripoli, one grain was ſoluble in concentrated vitriolic acid, two in diluted vitriolic acid, three in ſpirit of ſalt, five in ſpirit of nitre, eleven in aqua regia, and ſeven grains in cauſtic fixed alkali.

Some mercury is put into a glaſs-retort, and upon it is poured an equal weight of concentrated vitriolic acid, or more, according to the degree of concentration of this acid. Theſe matters are to be diſtilled together in a ſand-bath till nothing remains in the retort but a dry ſaline ſubſtance, which is a combination of mercury with vitriolic acid. The union of theſe two matters cannot be directly effected but by this proceſs, becauſe the vitriolic acid cannot attack mercury unleſs it be highly concentrated, and becauſe this concentration cannot be performed ſo well in open as in cloſe veſſels. *See* CONCENTRATION. Beſides, the heat in this operation favors conſiderably the action of the acid upon the mercury. The acid which paſſes into the receiver during the diſtillation, is very ſuffocating and ſulphureous; which qualities it receives from the phlogiſton of the mercury.

The white ſaline maſs left at the bottom of the retort is to be put into a large veſſel, and upon it large quantities of hot-water are to be poured at ſeveral different times. This water weakens the acid, takes it from the mercury, which is then precipitated towards the bottom of the veſſel in form of a very ſhining yellow citron-colored powder. This yellow mercurial powder, having been well waſhed, is called *turbith-mineral*, and is a very powerful emetic.

The water with which it is waſhed contains the acid that was united with the mercury; but it alſo contains a little mercury, that remains in a ſaline ſtate, and is ſoluble in water, by means of the very large quantity of acid.

Moſt chemiſts, eſpecially Mr. Rouelle, have believed that a portion of vitriolic acid remains united with the turbith mineral, but too little to render it ſoluble in water. On the contrary, Mr. Beaumé, having examined this matter, affirms that turbith mineral contains no acid, when it has been ſufficiently waſhed; and that by frequently boiling this preparation in a large quantity of diſtilled water, not a veſtige of acid will adhere to it.

Turbith mineral may alſo be made, by precipitating mercury from its ſolution in nitrous acid by means of vitriolic acid, or of ſome vitriolic ſalt. For this purpoſe the nitrous acid muſt be well ſaturated with mercury: for if it contains any unſaturated acid, no turbith mineral will appear upon adding either vitriolic ſalts or pure vitriolic acid. Hence miſtakes may be committed in making experiments to diſcover the preſence of vitriolic acid by means of a ſolution of mercury, as is frequently done.

We ought alſo to obſerve, that turbith mineral becomes yellow only by being deprived of the adhering vitriolic acid, and that it remains white till it has been waſhed with a large quantity of water; in general, the more perfectly it is deprived of acid, the deeper yellow color it acquires.

Turbith mineral has been formerly celebrated for the cure of the venereal diſeaſe, but it is now little uſed, becauſe preferable mercurial remedies have been diſcovered. *See* ACID (VITRIOLIC), *and* MERCURY.

DCCVII. TURPENTINE. (*l*)

(*l*) TURPENTINE is a reſinous juice extracted from ſeveral trees. Sixteen ounces of Venice turpentine being diſtilled with water, yielded four ounces and three drams of eſſential oil; and the ſame quantity diſtilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is diſtilled or boiled with water till it becomes ſolid, it appears yellowiſh; when the proceſs is further continued, it acquires

DCCVIII. TUTENAG. (m)

a reddiſh brown color. In the firſt ſtate it is called boiled turpentine, and in the ſecond, colophony or common reſin. On diſtilling ſixteen ounces in a retort with an open fire encreaſed by degrees, we obtain, firſt, four ounces of a limpid colorleſs oil; then two ounces and two drams of a thicker yellow oil; and laſtly, two ounces and a dram of a dark-browniſh red empyreumatic oil, of the conſiſtence of a balſam, and commonly diſtinguiſhed by that name.

The *eſſential oil* commonly called *ſpirit of turpentine* cannot without ſingular difficulty be diſſolved in ſpirit of wine, though turpentine itſelf is eaſily ſoluble in that ſpirit. One part of the oil may be diſſolved in ſeven parts of rectified ſpirit of wine; but on ſtanding a while, the greateſt part of the oil ſeparates and falls to the bottom. *Neuman.*

(m) TUTENAG. This name is given in India to the ſemi metal *zinc*. It is alſo ſometimes applied to denote a white metallic compound brought from China, called alſo *Chineſe copper*, the art of making which is not known in Europe. It is the beſt imitation of ſilver which has been made. It is very tough, ſtrong, malleable, may be eaſily caſt, hammered and poliſhed; and the better kinds of it, when well manufactured, are very white, and not more diſpoſed to tarniſh than ſilver is.

V.

DCCIX. VALERIAN. (n)

DCCX. VENUS is the name of a planet, which chemiſts have alſo applied to ſignify copper.

DCCXI. VERDIGRISE. Verdigriſe is copper corroded and reduced to a very beautiful green ruſt, by a vinous acid. This matter, which is very uſeful to painters, is conveniently manufactured at Montpellier; the wines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following proceſs for making verdigriſe, is deſcribed by Mr. Monet of the Royal Society of Montpellier, and is publiſhed among the Memoirs of the Academy for the years 1750 and 1753.

Vine-ſtalks well dried in the ſun are ſteeped during eight days in ſtrong wine, and afterwards drained. They are then put into earthen pots, and upon them wine is poured. The pots are carefully covered. The wine undergoes the acetous fermentation, which in ſummer is finiſhed in ſeven or eight days, but requires a longer time in winter, although this operation is always performed in cellars. When the fermentation is ſufficiently advanced, which may be known by obſerving the inner ſurface of the lids of the pots, which during the progreſs of the fermentation is continually wetted by the moiſture of the riſing vapors, the ſtalks are then to be taken out of the pots. Theſe ſtalks are by this method impregnated with all the acid of the wine, and the remaining liquor is but a very weak vinegar. The ſtalks are to be drained during ſome time in baſkets, and layers of them are to be put into earthen pots with plates of Swediſh copper, ſo diſpoſed that each plate ſhall reſt upon and be covered with layers of ſtalks. The pots are to be covered with lids, and the copper is thus left expoſed to the action of the vinegar, during three or four days or more, in which time the plates become covered with verdigriſe. The plates are then to be taken out of the pots, and left in the cellar three or four days; at the end of which time they are to be moiſtened with water, or with the weak vinegar above-mentioned, and left to dry. When this moiſtening and drying of the plates has been thrice repeated, the verdigriſe will be found to have conſiderably encreaſed in quantity, and it may then be ſcraped off for ſale.

(n) VALERIAN. An ounce of the dry root of valerian yielded with rectified ſpirit of wine three drams and ſix grains of reſinous extract, and the ſame quantity with water yielded four drams and twenty-one grains. The diſtilled ſpirit is ſlightly, and the diſtilled water is ſtrongly impregnated with the ſmell of the valerian, but no ſeparable oil is obtained. The moſt active preparation is the ſpirituous extract, which contains all the uſeful matter of the root. *Neuman.*

A ſolution or eroſion of copper, and conſequently a verdigriſe, may be prepared by employing ordinary vinegar, inſtead of wine, as is directed in the above proceſs. But it would not have the unctuoſity of ordinary verdigriſe, which quality is neceſſary in painting. Good verdigriſe muſt be prepared by means of a vinous acid, or ſolvent, half acid, and half ſpirituous. Accordingly, the ſucceſs of the operation depends chiefly on the degree of fermentation to which the wine employed has been carried: for this fermentation muſt not have been ſo far advanced that no ſenſibly vinous or ſpirituous part remained in the liquor.

Verdigriſe is uſed for painting, as it furniſhes a fine green color, when mixed with oil. It enters alſo as an ingredient into ſeveral plaiſters and ointments. In Chemiſtry, verdgriſe is uſed for the extraction of radical vinegar, and for the preparation of *cryſtals of verdigriſe*, or *of Venus*. *See* CRYSTALS *of* VENUS, COPPER, *and* VINEGAR.

DCCXII. VERDITER (*o*).

DCCXIII. VESSELS (CHEMICAL) *and* UTENSILS.

We have ſhewn at the article LABORATORY, how a chemical laboratory ought to be diſpoſed, and the principal utenſils with which it ought to be furniſhed. At the article FURNACES, we have mentioned whatever is eſſential to be known concerning thoſe inſtruments. Laſtly, we have deſcribed under each particular name, the principal veſſels employed in chemical operations. Nothing therefore remains but to make here a kind of enumeration, uſeful to thoſe who would furniſh a laboratory; which enumeration may be conſidered as a compleat ſupplement to that which is given at the article LABORATORY.

(*o*) VERDITER is a blue pigment obtained by adding chalk or whiting to the ſolution of copper in aqua fortis. It is prepared by refiners of ſilver, who employ for this purpoſe the ſolution of copper, which they obtain, in the proceſs of parting, by precipitating ſilver from aqua fortis with plates of copper. *See* PARTING. It is ſaid that a fine coloured verditer cannot be obtained from a ſolution of copper prepared by diſſolving directly that metal in aqua fortis; and that the ſilver is neceſſary. We know that it is actually made by the refiners only. Dr. Merret ſays that it is prepared in the following manner: a quantity of whiting is put into a tub, and upon this the ſolution of copper is poured. This mixture is to be ſtirred every day for ſome hours together till the liquor loſes its color. The liquor is then to be poured off, and more ſolution of copper is to be added. This is to be repeated till the whiting has acquired the proper color. Then it is to be ſpread on large pieces of chalk, and dried in the ſun.

The ancient chemiſts, and eſpecially the alchemiſts, have invented veſſels of many various kinds and whimſical ſhapes, ſuited to their ſeveral operations. But now the number and variety of thoſe veſſels are much diminiſhed, either becauſe modern chemiſts have not ſo much patience for ſuch tedious and perplexed operations as the alchemiſts had, or becauſe they have found that their operations can be performed with veſſels of a ſimpler form, and leſs various. Accordingly the veſſels required in a laboratory are few and ſimple, which is certainly an advantage. The chief of theſe veſſels are,

Copper Alembics, with their *refrigeraries*, *worms*, and *receivers*. *See all theſe words, and* PLATE I.

Alembics of Glaſs, of *Stone*, and *Earthen-Ware*, of different ſizes, with their *receivers*, which are matraſſes with longer or ſhorter necks. *See* PLATE I.

Adopters, which are ſmall receivers with two necks, the uſe of which to encreaſe the diſtance of the receiver from the diſtilling veſſel and the furnace.

Aludels of Earthen Ware. *See* PLATE I.

A Balance. *See this word.*

Balloons, which are matraſſes with large bellies and ſhort necks. They are uſed as receivers. *See* BALLOONS.

Bottles of all kinds and ſizes. A great number of theſe is required in laboratories, to contain the different liquors, and ſubſtances that are volatile, deliqueſcent, or corroſive. The moſt neceſſary of theſe are large glaſs bottles containing three, four, ſix pints, or more, of any form, for containing thoſe matters that are uſed in large quantities. *Cryſtal-glaſs Bottles* with glaſs ſtopples, to contain all volatile or corroſive liquors. The ſmall bottles or *Phials* are very convenient, and may be uſed as matraſſes in many ſmall operations. *See* MATRASS.

Glaſs Jars are cylindrical veſſels uſeful for containing many dry and not volatile ſubſtances. Their mouths are generally cloſed with cork or with paper. Large jars are convenient for the mixing of liquors, for precipitations, &c. A great number of theſe is required of different ſizes.

Baſons of metal. Theſe are uſeful for evaporations. They are generally of copper; but as this metal is very liable to be corroded by ſaline matters, a ſilver baſon is very convenient.

Capſules, or *Diſhes* of glaſs, of ſtone-ware, and of cryſtal-glaſs, which are the beſt of any. Theſe are uſed in the evaporations of corroſive matter capable of acting upon metals. Some alſo are made of crucible-earth, and of plate iron, which are employed for containing the ſand of ſand-baths.

The *Cone*. This is a caſt-iron veſſel of the form of a hollow cone, to the point of which is fixed a pedeſtal, that it may ſtand firmly, with its point turned downwards. The uſe of this cone is to receive metallic matters melted with other ſubſtances, all which being poured into it, the metallic parts of the mixture ſink by their weight to the point of the inverted cone, and are there collected in form of a regulus. The cone ought to be heated, and greaſed with tallow, before the melted matters are poured into it.

Retorts. *See that word.*

Crucibles are kinds of earthen pots of a cylindrical, conical, or triangular figure, uſed for fuſions of all kinds. They ought to be covered with lids. *See* POTTERY.

Glaſs Funnels. Theſe ought to be of various ſizes; and are neceſſary for ſmall filtrations, and for the pouring of liquors into bottles.

Ingot-moulds are iron veſſels of a certain thickneſs, of the form of hollow ſemi-cylinders, to which a handle is annexed. The ſurface of their ſemi-cylindrical cavities ought to be very ſmooth. They are of various ſizes. The uſe of theſe veſſels is to receive melted metals into their cavities, the form of which is given to the metals, which are then called *ingots*. We ought always to heat and to greaſe theſe moulds before the melted metal is poured into them. *See* PLATE I. *Fig.* 11.

Mortars. See that word.

Matraſſes are long-necked bottles. Some of theſe have round, and ſome flat bottoms. Some are ſhaped like an egg, and thence are called *philoſophic eggs*. Matraſſes are uſed for *ſolutions and digeſtions.*

Muffles. Theſe veſſels, which ought to be made of crucible earth, have the form of a hollow cylinder divided in the direction of its axis, and cloſed on all ſides, excepting its front. This veſſel repreſents an oblong arch or vault, the hinder part of which is cloſed by a ſemicircular plane, and the lower part or floor of which is a rectangular plane. It is a little oven that is placed horizontally in eſſay and enamelling furnaces, ſo that its open ſide correſponds with the door of the fire-place of the furnace. Under this arched oven ſmall cupels or crucibles are placed; and the ſubſtances contained are thus expoſed to heat without contact of fuel, ſmoke, or aſhes. *See* FURNACE (ESSAY); PLATE I. *Fig.* 9, and PLATE II. *Fig* 1.

Pelicans. See that word, and PLATE I. *Fig.* 6.

Receivers. See that word, and PLATES I. *and* II.

Circulatory Veſſels. Two matraſſes are ſo called, into the largeſt of which the matter to be operated upon is to be introduced, and the neck of the ſmaller matraſs is to be fitted into the neck of the former, ſo as to be a kind of ſtopple to it. The joining is to be cloſed with a lute ſuitable to the vapors intended to circulate. By means of this apparatus, one or more ſubſtances may be digeſted during a long time without any evaporation, becauſe the vapors which riſe are condenſed in the ſmall matraſs that ſerves as a ſtopple, and continually fall back upon the matter in the great matraſs. It is, as we ſee, a very ſimple apparatus, which produces the ſame effect as the pelican.

Subliming Veſſels. This name was formerly given to a long-necked matraſs, which being covered with a capital, formed a kind of alembic. It was employed in the diſtillation and rectification of very volatile ſubſtances; but ſince we have found that the length of the neck of an alembic is quite uſeleſs, theſe have been quite abandoned. Accordingly, the true ſubliming veſſels are thoſe that are actually employed in ſublimations. *See* ALEMBICS, ALUDELS, MATRASS, *and* SUBLIMATION.

DCCXIV. VINEGAR. Vinegar is a vegetable ſpirituous acid, produced by the ſecond degree of fermentation, or by that fermentation which ſucceeds the ſpirituous, and is called the *acid* or *acetous fermentation.*

From this definition it appears, that wine only or vinous liquors can be changed into true vinegar. Every liquor which has completely undergone the ſpirituous fermentation, is ſpontaneouſly and neceſſarily diſpoſed to the acid fermentation. Accordingly every wine does continually tend to become vinegar, and actually is changed into vinegar, ſooner or later, according to circumſtances; unleſs this change be prevented by ſome obſtacle to fermentation in general. Vinegar may therefore be made not only from wine of grapes, but alſo from cyder, beer, and, in a word, from all other wines. But as the wine of grapes is preferable for this purpoſe, we ſhall deſcribe the method of converting it into vinegar.

As vinegar is produced by a fermentation, its qualities depend much on the method of exciting and of conducting that fermentation. The wine which is generally converted into vinegar, and which for its cheapneſs is generally employed for this purpoſe, is ſuch as has already become ſour; although the better and the more ſpirituous the wine is, and alſo the more of the vinous ſpirit that can be retained in the vinegar, the better and ſtronger this will be. Becher ſays, in his *Phyſica Subterranea*, that having digeſted wine in order to convert it into vinegar in a bottle hermetically ſealed, he found, that although a longer than the ordinary time was required, the vinegar produced was much ſtronger then when free air is admitted. Mr. Cartheuſer alſo affirms, that the ſtrength of vinegar may be much encreaſed by adding ſome aqua vitæ to the wine before it is expoſed to the acetous fermentation.

Different methods are practiſed by manufacturers for making vinegar, who are generally believed to be poſſeſſed of ſome ſecret for that purpoſe. Nevertheleſs no more ſeems requiſite in the preparation of good vinegar, than to employ good wine, and to conduct the fermentation in the moſt advantageous method; in the ſame manner as good wine can only be made from good muſt, and by a well conducted fermentation. The principal part of theſe operations is performed by nature.

The method of making vinegar conſiſts in mixing the wine to be fermented with its dregs, and its tartar, and in expoſing this liquor to a heat of about eighteen or twenty degrees. This fermentation ſeems to require more heat than the ſpirituous. It alſo excites more heat and tumult; and although it ought to be allowed to proceed briſkly, yet it is neceſſary from time to time to check it.

Boerhaave deſcribes, in his Elements of Chemiſtry, the following proceſs, which ſeems to be well contrived, for the making of vinegar.

Take two large oaken vats or hogſheads, and in each of theſe place a wooden grate or hurdle, at the diſtance of a foot from the bottom. Set the veſſel upright, and on the grate place a moderately cloſe layer of green twigs, or freſh cuttings of the vine. Then fill up the veſſel with the footſtalks of grapes, commonly called the *rape*, to within a foot of the top of the veſſel, which muſt be left quite open.

Having thus prepared the two veſſels, pour into them the wine to be converted into vinegar, ſo as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled veſſel with liquor from that which is quite full, and which will now in its turn be left only half-full. Four-and-twenty hours afterwards repeat the ſame operation, and thus go on, keeping the veſſels alternately full and half-full during every twenty-four hours, till the vinegar be made. On the ſecond or third day there will ariſe, in the half-filled veſſel, a fermentative motion, accompanied with a ſenſible heat, which will gradually increaſe from day to day. On the contrary, the fermenting motion is almoſt imperceptible in the full veſſel, and as the two veſſels are alternately full and half-full, the fermentation is by that means, in ſome meaſure, interrupted, and is only renewed every other day in each veſſel.

When this motion appears to have entirely ceaſed, even in the half-filled veſſel, it is a ſign that the fermentation is finiſhed; and therefore the vinegar is then to be put into caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerates or checks this, as well as the ſpirituous fermentation. In France it is finiſhed in about fifteen days, during the ſummer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Mr. Reaumur's Thermometer, the half-filled veſſel muſt be filled up every twelve hours; becauſe if the fermentation be not ſo checked in that time, it will become violent, and the liquor will be ſo heated, that many of the ſpirituous parts, on which the ſtrength of the vinegar depends, will be diſſipated; ſo that nothing will remain, after the fermentation, but a vapid liquor, ſour indeed, but effete. The better to prevent the diſſipation of the ſpirituous parts, it is a proper and uſual precaution to cloſe the mouth of the half-filled veſſel, in which the liquor ferments, with a cover made alſo of oak-wood. As to the full veſſel, it is always left open, that the air may act freely on the liquor it contains: for it is not liable to the ſame inconveniencies, becauſe it ferments but very ſlowly.

In the *Dictionnaire Portatif des Arts et Metiers*, another method is deſcribed, by which a very good vinegar is commonly made at Paris from the lees of wine. For this purpoſe all the wine contained in the lees is preſſed out, and put into large caſks, the bung-holes of which are left open. Theſe caſks are put into a hot place; and if the fermentation proceeds too faſt, it muſt be checked by adding more freſh wine. This proceſs is very ſimilar to the foregoing.

The appearances which accompany the acetous fermentation reſemble much thoſe that occur in the ſpirituous fermentation. In both fermentations, an inteſtine motion, a ſwelling, a hiſſing noiſe, and an ebullition, may be perceived. There are nevertheleſs eſſential differences between them. Beſides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is ſcarcely ſenſible, while that produced by the latter is conſiderable. Secondly, we have reaſon to believe, that the vapour which exhales from vinegar during fermentation is not noxious, as the vapor of fermenting wine is; at leaſt, it has not been obſerved to produce ſuch bad effects. On the contrary, as the acid of vinegar more and more diſengages or unfolds itſelf, it ſeems to acquire more power to bind and retain the inflammable principle, which is the truly dangerous part of theſe vapors. Laſtly, vinegar does not depoſit tartar as wine does, even although it has been made with wine that had not depoſited its tartar. But the ſediment of vinegar is a viſcid, oily, and very putreſcent matter. The grape-ſtalks uſed in the making of vinegar, to promote and encreaſe the fermentation, are covered over with this matter during the operation. They are generally waſhed clean, and carefully preſerved, to promote the fermentation of more vinegar; becauſe the acid with which they are ſoaked acts powerfully as a leaven or ferment. The caſks alſo which have been uſed for the preparation of vinegar are to be cleanſed from the above-mentioned viſcid matter, and kept for the ſame uſe, as they are rendered fitter than new caſks for the preparation of vinegar.

When the acetous fermentation is finiſhed, the nature and the character of the liquor that has undergone it are totally changed. Wine has a taſte and ſmell, partly ſpirituous, ſomewhat acid; but in good wine the ſpirit ſo much prevails over the acid, that the latter is ſcarcely perceptible. The taſte and ſmell of vinegar alſo is partly acid and partly ſpirituous; but the former quality ſo entirely prevails, that the latter is almoſt totally concealed.

We cannot form any very clear and diſtinct knowledge of the manner in which Nature performs theſe changes in fermenting liquors. The properties of wine and vinegar prove, that the acetous fermentation unfolds in a very ſingular manner the acid parts of wine, and intimately combines them with the inflammable ſpirit. Hence, by changing wine into vinegar, its ardent ſpirit is ſo covered by the large quantity of acid, that it is no longer perceptible; that it now cannot affect the head and intoxicate; and that if it be diſtilled, the firſt liquor that riſes with a heat leſs than that of boiling water is not an ardent ſpirit, as when wine is diſtilled, unleſs the vinegar be too new, and the acetous fermentation has not been completely finiſhed; in which caſe the vinegar yields a little ardent ſpirit: but when old vinegar is diſtilled, the liquor that riſes firſt is a ſlightly acid phlegm, which contains the moſt volatile, the moſt odoriferous, and the moſt ſpirituous part of the vinegar.

The acid of vinegar is employed in many chemical and pharmaceutical preparations, for which not common vinegar, but the acid ſpirituous part of vinegar that is obtained by diſtillation, called *diſtilled vinegar*, is chiefly employed.

The proceſs of diſtilling vinegar is very ſimple. A quantity of good ordinary vinegar is put into a large cucurbit or ſtill, which ought to be made of ſtone-ware, and not of metal, as the acid of vinegar is capable of acting upon moſt metals. This cucurbit is ſunk in a deep furnace, ſo that five or ſix fingers breadth only near its neck appears. The neck is to be carefully luted with clay all round the furnace, that the capital may not be heated too much. A capital and a glaſs receiver are then to be fitted, and the diſtillation is to be begun, with a very gentle heat. The acid ſpirituous liquor paſſes by drops into the receiver. This liquor is white, tranſparent, penetrating, ſomewhat empyreumatic, and diſengaged from an acid, but not ſpirituous ſubſtance, and alſo from an extractive ſaponaceous matter, both which are contained in ordinary vinegar. Theſe latter ſubſtances remain in the ſtill with the coloring matter, and form together an extremely acid extract of vinegar. This reſiduum contains alſo ſome tartar, and by incineration yields much fixed alkali, as all matters belonging to vines, grapes, or wine, do.

We ſhould be much miſtaken if we believed that the acid ſpirituous portion of the vinegar that riſes in this diſtillation, is a ſtronger acid than the vinegar itſelf. Vinegar is not diſtilled with an intention to concentrate it, but only to diſengage it, as we have ſaid, from its extractive part. The acid which this part contains is not, properly ſpeaking, vinegar, but is oily, not ſpirituous, leſs volatile than the former, or even than water. Accordingly, the acid obtained in this diſtillation, when well conducted, is more ſpirituous and alſo more watery than the acid of the reſiduum.

Chemiſts have attempted different methods of concentrating diſtilled vinegar. Stahl has taught us the beſt method for depriving it of its water without any alteration. This method conſiſts in expoſing it to a cold ſufficiently intenſe to freeze its watery part, which is afterwards ſeparated in lumps of ice from the more acid part. Thus the acid of vinegar may be conſiderably concentrated. *See the* CONCENTRATION *of* VINEGAR *by* FROST.

The acid of vinegar may be more effectually concentrated by combining it with alkalis, earths, and metals, as any other acid may. Thus by drying perfectly neutral acetous ſalts with fixed baſes, and afterwards by decompoſing them, either by the mere action of the fire, or by means of concentrated vitriolic acid, we obtain the ſtongeſt acetous acid that can be produced. This acid is called *radical vinegar*. *See* SPIRIT *of* VENUS.

The acid of vinegar diſſolves all ſubſtances upon which other acids can act, and forms with them neutral ſalts, ſome of which have particular names, but which all might be called *acetous ſalts*.

With calcareous earth this acid forms ſalts that in cryſtallizing ſhoot into ſilky ramifications and vegetations. Theſe ſalts are named from their earthy baſes, *ſalt of chalk*, *ſalt of crabs-eyes*, &c.

With fixed vegetable alkali it forms a very pungent and very deliqueſcent ſalt, called *regenerated tartar*, or *terra foliata tartari*. *See* TERRA FOLIATA.

With fixed mineral alkali it forms a neutral cryſtallizable ſalt.

With volatile alkali it forms *an acetous ammoniacal ſalt*, called *ſpirit of Mindererus*.

All the combinations of the acetous acid with metallic ſubſtances have not been yet examined. The combinations of this acid with lead and with copper are beſt known, becauſe they furniſh ſeveral preparations uſed in painting, and ſome other arts. This acid united with copper forms *verdigriſe* and *cryſtals of Venus*; and with lead forms *ceruſs*, and *ſalt or ſugar of lead*. *See theſe ſeveral articles*. The vinegar in which lead is diſſolved is called *vinegar of lead*, and is ſometimes uſed as a coſmetic, for repelling cutaneous eruptions. But this coſmetic ought not to be employed but under the direction of a prudent phyſician, as it may occaſion a dangerous tranſlation of the morbid humour to other parts.

Mercury diſſolved firſt by nitrous acid, and afterwards precipitated by fixed alkali, is quickly ſoluble in vinegar, with which it forms a mercurial acetous ſalt. The cryſtals of this ſalt are ſhining ſilver-like plates, not very ſoluble in water. *See* MERCURY.

Vinegar very much concentrated, as the rectified ſpirit of Venus, or radical vinegar, being diſtilled with equal parts of highly rectified ſpirit of wine, furniſhes a liquor which has all the eſſential characters of ether, or rather is a true ether, called *acetous ether*. The diſcovery of this ether was lately made by the Count de Lauraguais. *See* ETHER (ACETOUS).

Vinegar being an oily, ſpirituous, vegetable acid is much weaker than mineral acids, which are leſs compounded. Accordingly all acetous neutral ſalts may be decompoſed by any mineral acids, excepting the vitriolic acid when very much ſulphurated, which cannot be conſidered as a pure acid.

According to Mr. Gellert's table, the affinities of the acetous acid are in the following order: Inflammable principle, zinc, iron, copper, lead, and biſmuth.

Gold, ſilver, tin, and mercury, are marked in this table as incapable of uniting with this acid.

Vinegar is very uſeful, not only in ordinary life as an agreeable ſeaſoning for many kinds of food, but alſo in medicine, in chemiſtry, and in ſeveral arts.

This acid is in general antiſeptic, and is conſidered as inciſive and aperitive. It is uſed as a vehicle in many preparations which poſſeſs theſe qualities. Thus *ſimple oxymel* is a ſyrup made of honey and vinegar. Such alſo are *oxymel of ſquills*, and ſeveral other compound vinegars for the uſe not only of medicine, but alſo of the toilette; receipts for all which are found in diſpenſatories. A very important medicinal virtue has been attributed to vinegar, namely, that of curing the canine madneſs. Mr. Buchoz, in a work entitled, *An Hiſtorical Treatiſe of Plants growing in Lorraine and the Three Biſhopricks*, affirms, that ſeveral ſucceſsful trials have aſcertained the efficacy of vinegar againſt the ill effects ariſing from the bite of mad dogs, when it is given in the quantity of a pound each day, divided into three doſes; one to be taken in the morning, another at noon, and the third in the evening. The diſcovery of this quality of vinegar was made accidentally at Udina, in Trioul, a province belonging to Venice, by an inhabitant of that town, who having been ſeized with canine madneſs, was cured by drinking a glaſs of vinegar by miſtake, inſtead of ſome medicine that had been prepared for him.

We have already mentioned the uſe of vinegar in ſeveral chemical preparations, particularly of ceruſs and of verdigriſe.

DCCXV. VINEGAR (DISTILLED). This is the ſpirituous acid of vinegar obtained by diſtillation. *See the preceding article.*

DCCXVI. VINEGAR (RADICAL). *See* SPIRIT *of* VENUS.

DCCXVII. VINEGAR *of* LEAD. Is a ſolution of lead or of ceruſs in diſtilled vinegar. *See the articles* LEAD *and* VINEGAR.

DCCXVIII. VITRIFICATION. Vitrification is one of the moſt curious and moſt important operations in chemiſtry. The product of this operation is Glaſs; a matter which, when well made, is valuable for its great hardneſs, beauty, and perfect tranſparency. Theſe principal and eſſential qualities of glaſs render it very extenſively uſeful in ordinary life, in natural philoſophy, in chemiſtry, and in many arts. Almoſt any form may be given to glaſs, and all kinds of veſſels and utenſils may be formed of it, which are capable of reſiſting the moſt powerful corroſives and ſolvents. Glaſs is capable of receiving and preſerving the fineſt poliſh. Its properties of tranſmitting and refracting the rays of light, and of reflecting theſe rays when one of its ſurfaces is covered with a metallic coat, render it very uſeful for conſtructing mirrors, teleſcopes, microſcopes, and all kinds of optical glaſſes; for collecting, ſeparating, and decompoſing the rays of light; and for exhibiting many wonderful catoptrical and dioptrical appearances and experiments. If to theſe admirable properties we add that of imitating the many brilliant precious ſtones, opake or tranſparent, we ſhall eaſily be convinced that perfect glaſs is one of the moſt beautiful and excellent productions of human induſtry.

The art of making glaſs is dependant on chemiſtry in all its parts. In its principles it is ſimple, but extenſive in its detail, and difficult in its practice. The extent of this art does not permit us to enter into the particulars, or into *its ſeveral branches. In this article we ſhall only endeavor to explain the chemical principles upon which the art depends, and which may direct experimental philoſophers as well as intelligent artiſts in their reſearches to improve it.*

Perfect glaſs, or the moſt beautiful factitious cryſtal, is perfectly ſimilar in appearance to the whiteſt and moſt tranſparent natural vitrifiable ſtones. The only ſenſible difference between theſe natural and artificial productions is, that the latter are much leſs hard and more fuſible than natural cryſtal, or any other vitrifiable ſtone. In fact, pure glaſs or artificial cryſtal is eſſentially of the ſame nature as vitrifiable ſtones; or we may rather ſay, that it is vitrifiable earth itſelf rendered more fuſible only by certain additions, as we ſhall ſoon ſhew.

The moſt ſimple and elementary of all earths, called by chemiſts *vitrifiable earth*, forms the hardeſt and moſt tranſparent of all natural bodies, when its integrant parts are united together in a due ſtate of aggregation: but the parts of vitrifiable earth cannot form this aggregation, unleſs they have been previouſly ſo much ſeparated from each other, that they poſſeſs a mobility which enables them to unite together according to their natural tendency: the integrant parts of elementary earth may acquire this mobility by two methods; namely, by the interpoſition of the parts of water, or of thoſe of fire.

Almoſt all the vitrifiable ſtones that we know, as diamonds, rock-cryſtal, and other hard tranſparent ſtones, appear to have been once diſperſed in infinitely ſmall molecules through much water, from which they have afterwards been depoſited, and then have united together and formed the very hard tranſparent maſſes which we now ſee. The regular and uniform cryſtallization of theſe precious ſtones is an evident proof of this truth.

Poſſibly ſome of theſe ſtones may have been formed by fire, and by a true fuſion. Perhaps even this terreſtrial globe has been once, as Mr. de Buffon thinks, one ſphere of melted glaſs, or one immenſe diamond, the outer cruſt of which only has been changed by the elements, while the interior parts ſtill remain in their vitrified ſtate (*p*): but we certainly know, that of the two abovementioned methods by which pure ſolid maſſes of vitrifiable earth may be formed, that of the diviſion and elaboration by water cannot be practiſed by human art, on account of the many ages required for the operation.

By the ſecond method, namely, *fuſion*, the time required for which is better adapted to the ſhortneſs of our lives, we certainly might, with a ſufficient degree of heat, melt vitrifiable earth, and all other kinds of earths; ſince theſe, when ſufficiently purified, are reduced to the nature of vitrifiable earth; and we might convert theſe earths into maſſes of cryſtal, or of hard tranſparent ſtones,

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(*p*) Mr. Buffon conjectures, that the earth, as alſo the other planets, might have been parts knocked off from the ſun by a comet falling upon its ſurface; that they received from the impulſe of the comet their progreſſive motion; and alſo, by the obliquity of the ſtroke, their motion round their own axes; that the earth was then in a vitrified and fluid ſtate; and that a vapor exhaled from its ſurface by the violent heat, the groſſer parts of which, being afterwards condenſed, formed water, and the leſs denſe remaining ſuſpended formed air. We have not heard that many philoſophers have adopted this theory of the formation of the planets, as perfect as the natural precious ſtones. In a word, nothing but a heat ſufficiently intenſe is required to melt any earthy matter, and to convert it into a diamond, as brilliant and as hard as the moſt perfect natural diamonds: but here a great, and hitherto unſurmountable difficulty occurs, namely, to produce a heat ſufficiently intenſe to melt the moſt pure and ſimple vitrifiable earth; for the moſt violent heat that art has ever produced is inſufficient to melt even many of the common impure earths and ſtones, and is therefore much leſs capable of melting that earth, which, becauſe it is the ſimpleſt and pureſt, is alſo the moſt unfuſible of all natural bodies. *See* Earth.

Hence we conclude, that although we know by what means the parts of the pureſt earthy principle may be ſo united as to form bodies ſimilar to the natural precious ſtones, yet we cannot poſſibly put theſe means in execution: but if we cannot artificially produce ſolid maſſes of pure earth exactly ſimilar in all their properties to the natural precious ſtones, we can however very well imitate theſe beautiful natural productions, not in their hardneſs and unfuſibility, but in their tranſparency and luſtre; that is, in their moſt obvious and ſtriking qualities, by means of compoſitions of glaſs or factitious cryſtal. The ſolution of this problem is founded on the following principles.

Firſt, pure and elementary earth, which makes the principal baſis of all vitrifications, and therefore called vitrifiable earth, is indeed unfuſible with regard to us: but we know, that certain very fuſible ſubſtances are capable of uniting intimately with this earth, and of communicating to it ſome of their fuſibility; ſo that by their means we may reduce it to a perfect fuſion.

Secondly, the ſubſtances capable of acting upon the earthy principle are the inflammable principle or phlogiſton, and ſeveral ſaline matters: but we may remark, that as theſe ſubſtances do only act as fluxes by uniting intimately with the vitrifiable earth, and while they themſelves make part of the glaſs; and alſo, as the integrant parts of theſe fluxes are not capable of forming either with each other, or with the parts of vitrifiable earth, ſo ſtrong an adheſion as that which can be formed between the parts of the pure vitrifiable earth; it follows, that all factitious cryſtal muſt be much leſs hard than natural cryſtals, or other hard ſtones; ſince theſe contain only pure vitrifiable earth.

Thirdly, in conſequence of the principle, that all compound bodies partake of the properties of their component parts, factitious cryſtals ought to partake ſo much more of the properties of inflammable and ſaline matters, and ought to be removed ſo much more from thoſe of pure vitrifiable ſtones, as they contain a larger quantity of thoſe matters. Accordingly we find, that the ſmaller quantity of flux that is contained in glaſs, the greater hardneſs, luſtre, and reſemblance to natural ſtones it has, provided the fuſion has been compleat. Thus glaſs is ſo much more perfect, as it poſſeſſes more of the properties of vitrifiable earth.

Theſe principles, which are inconteſtable, being once underſtood, are eaſily applicable to the art of making glaſs, as we ſhall ſhew: ſince, if we could produce a fire ſufficiently intenſe, and had furnaces and veſſels capable of ſuſtaining it, we ſhould make glaſs equal to the precious ſtones; it is therefore evident, that the moſt important object in vitrification is to have furnaces capable of producing the greateſt heat, and pots or crucibles capable of reſiſting, during a long time, this heat, and alſo the action of the vitreſcent matter that they contain. At the articles of this Dictionary, CLAY and POTTERY, may be ſeen what are the beſt earths, or mixtures of earths, for the conſtruction of furnaces, and of pots or crucibles. We ſhall here only repeat, that theſe pots ought to be made entirely of the moſt refractory and pureſt clay, well waſhed and cleanſed from all ſandy, ferruginous, and pyritous matters, and mixed with a certain proportion of the ſame clay baked, and pounded not very finely. The quantity of baked clay that ought to be mixed with the crude clay, to prevent the pots from cracking when dried, or when expoſed to violent heat, is not abſolutely determined, but varies in different glaſs-houſes, according as the crude clay employed be more or leſs fat, as it is called: but Mr. D'Antic, Doctor of Phyſic, a very able chemiſt, and particularly converſant about every thing relating to the theory and practice of glaſs-making, in an excellent Memoir upon this ſubject, propoſes a very good method of aſcertaining the quantity of burnt clay that ought to be mixed with crude clay in the compoſition for pots and furnaces. This method conſiſts in mixing the burnt and crude clay in different proportions, and in forming cakes of theſe ſeveral mixtures, each of which is one inch in thickneſs, and four inches in each of the other two dimenſions. When theſe cakes have been ſufficiently and very ſlowly dried, and are expoſed to a violent heat, till they become as hard, and contract as much in their dimenſions as they can, they are to be then examined; and the cake which has ſuffered a diminution of its bulk equal only to an eighteenth part is made of the beſt proportions. According to the ſame author, moſt clays require that the proportion of the burnt ſhould be to the freſh as four to five.

The ovens and furnaces are different according to the quantity of materials to be vitrified. For experiments and eſſays, we know none better than the melting furnace deſcribed at the article FURNACE, and which muſt be heated with charcoal. In large works wood or foſſil coal are uſed, and the furnaces are ſo conſtructed that the flame of the fuel circulates and burns within very intenſely. As theſe furnaces vary much in different countries and glaſs-houſes, and as a deſcription would not be very intelligible without figures, we ſhall refer the reader to other works in which theſe ſeveral furnaces are deſcribed and repreſented, particularly to the French edition of Neri's Art of Making Glaſs, with Notes by Merret and by Kunckel, and to the above quoted Memoir of Mr. D'Antic. We ſhall here ſay only in general, that theſe furnaces are placed under large and lofty buildings called *halls*; that they are covered with a vaulted roof; and that they have no chimney, but only lateral openings through which the melted glaſs is drawn from the pots. Under theſe openings is built a kind of platform or banquette, on which the pots containing the glaſs ſtand, one of which is oppoſite to each opening. In the middle of the furnace, below the banquette, is a ſpace, a-croſs which iron bars are laid. In this ſpace, which communicates with a large cavity below, called the aſh-hole, the fuel is placed. In theſe furnaces, which have not any chimney, as we have ſaid, the fire is nevertheleſs very intenſe. This intenſe heat is occaſioned by the great capacity of the furnace, by means of which a ſtrong draught of air paſſes continually from the aſh-hole. Beſides, the flame, being vividly agitated by air, and not being drawn out of the furnace by any chimney, circulates in every direction within the furnace, and produces a very violent heat. Moſt glaſs-houſe furnaces have alſo hollow towers that communicate with the cavity of the furnace, and which therefore encreaſe the capacity of the whole. In theſe the heat is not nearly ſo intenſe as in the furnace. They are employed to contain the *fritt*, or the pieces of manufactured glaſs that are to be annealed. Such is the general diſpoſition of the furnaces of glaſs-houſes.

The good condition of the pots and furnaces is, as we have obſerved, the moſt important and eſſential matter to be conſidered in the operations of making glaſs. Next to that, is the conſideration of the kinds and proportion of the fluxes. Of theſe we may obſerve two kinds, namely, the inflammable and the ſaline. As we cannot obtain the pure inflammable principle, we muſt, when we intend that it ſhould enter into the compoſition of glaſs, chuſe for this purpoſe ſome of the earthy ſubſtances with which it is found naturally combined; and theſe are particularly metallic earths, which are beſt adapted for conveying phlogiſton into vitreous compoſitions: but all theſe earths are not equally fit for this purpoſe. All metals are compoſed of an earthy matter intimately combined with a ſufficient quantity of the inflammable principle to be very fuſible, and, at the ſame time, very opake. Some of theſe metals, namely, thoſe called *perfect*, are unalterable by fire, and cannot be entirely, or even partly, deprived of phlogiſton: but as every metallic ſubſtance is incapable of uniting with earthy matters, while it retains its metallic ſtate, therefore no perfect metal can be vitrified. The caſe is different with thoſe metallic ſubſtances, the phlogiſton of which may be burnt, or otherwiſe deſtroyed. The earths or calxes of moſt, perhaps of all combuſtible metals, when not perfectly deprived of all their phlogiſton, are capable of being reduced to a vitreous ſtate, by means of their remaining inflammable principle. As they are not then in a metallic ſtate, they can facilitate the fuſion of vitrifiable earths, may contract with theſe an intimate union, and reduce them to a ſtate of perfect vitrification: but theſe phlogiſticated calxes of imperfect metals promote vitrification more or leſs, according to their particular natures. Some of theſe, as, for inſtance, tin, cannot be without great difficulty brought to that preciſe degree of calcination that is neceſſary to vitrification; becauſe the heat required for this purpoſe deprives them of all their phlogiſton, and renders them in a high degree refractory. Others, in whatever manner they be calcined, either retain too little phlogiſton to be ſufficiently fuſible, although they ſtill retain enough to give them color; or if they be not calcined ſo much as to loſe their fuſibility, they cannot be melted but into opake maſſes, ſo nearly in a metallic ſtate that they cannot be united intimately with vitrifiable earths. Such, eſpecially, are the earths of iron and of copper.

Of all metallic earths, that of lead is fitteſt for vitrification. This metal, which contains a large portion of phlogiſton, is quickly deprived of ſo much of it, that it loſes its metallic ſtate, and is eaſily melted into a tranſparent vitreous maſs; but it has, at the ſame time, this remarkable property, that when once it has loſt as much phlogiſton as is neceſſary to diſpoſe it to vitrification, its calx ſtrongly retains as much of it as is neceſſary to give to it its greateſt degree of vitreſcibility; and that it may be ſooner diſſipated into vapors by the continued action of a very intenſe fire, than it can be changed into an earth totally dephlogiſticated, and conſequently refractory, like the calxes of tin and of regulus of antimony. Beſides, the fuſible earth of lead is one of theſe that retain the leaſt color. All theſe qualities render it preferable to any other metallic earth for the purpoſes of vitrification. The earth of biſmuth, which in the above-mentioned properties reſembles the earth of lead, may probably be employed with equal ſucceſs: but as the calxes of lead are much more common than thoſe of biſmuth, the uſe of this ſemi metal is not known to manufacturers of glaſs.

In whatever manner the calx of lead has been prepared, provided it be really in a calcined and not in a metallic ſtate, it may be uſed in vitrification. Accordingly, the grey calx, or aſhes of lead, maſſicot, red lead, litharge, ceruſs, and all the precipitates of lead, ſeparated from acids by unmetallic intermediate ſubſtances, being mixed with ſand or any other vitrifiable ſtone, and expoſed to a ſufficient degree of fire, do always promote the fuſion of theſe matters, and form with them glaſſes more or leſs hard and tranſparent, according to the ſtrength of the fire and the proportion of the ingredients.

The earth of lead conſtantly retains, as we have ſaid, enough of the inflammable principle to preſerve its fuſibility. When it is expoſed ſingly to the fire, it vitrifies with a very moderate heat. It has more phlogiſton than is requiſite for its vitrification. The fuſibility, fluidity, and activity of this glaſs of lead, when pure, are ſo great, that it cannot be contained in any crucible, all which it eaſily pervades: therefore pure glaſs of lead is never made. But as the calx of lead has more phlogiſton than is required for its own vitrification, it may divide this exceſs of inflammable principle with any unmetallic earths with which it is mixed, and thus may produce their fuſion and perfect vitrification. The glaſſes formed by a mixture of calx of lead with unmetallic earths have more conſiſtence, hardneſs, and leſs fuſibility, than pure glaſs of lead. The proportions of calx of lead and of ſand employed in theſe kinds of glaſs are from one part to two of calx of lead, to one of ſand, or of ground flints.

We may obſerve upon the ſubject of glaſſes that contain no other flux than phlogiſton or metallic earths, of lead, or of any other metal, that none of them are perfectly white, but are all more or leſs colored; becauſe phlogiſton is, as chemiſts know, the principle of colors. Secondly, theſe glaſſes have a greater denſity or ſpecific gravity than any natural cryſtalline ſtone, all metallic earths being heavier than any that are not metallic.

Thirdly, metallic glaſſes are generally ſomewhat leſs brittle, are leſs liable to be broken by the alterations of heat and cold, and have more of a certain ſmoothneſs, or, as it were, unctuoſity, not eaſily to be deſcribed, than glaſſes made altogether of unmetallic earths. Theſe properties can only be attributed to the inflammable principle, a pretty conſiderable quantity of which is united with them. As theſe latter qualities of glaſs are valuable, a certain quantity of calx of lead generally enters into the compoſition of moſt fine glaſſes, which are diſtinguiſhed from ordinary glaſs by the name *cryſtal-glaſs*.

From what we have ſaid concerning the properties of metallic earths in vitrification we may perceive, that the more calx of lead, or other metallic earth, enters into the compoſition of any glaſs, the more fuſible, ſoft, colored, and denſe this glaſs is; and reciprocally. The colors given to glaſs by calxes of lead are ſhades of yellow.

Saline ſubſtances are the ſecond kind of fluxes uſed in vitrification: but all theſe ſubſtances are not equally fit for this purpoſe; not that they are not all very fuſible, but for ſeveral reaſons hereafter to be mentioned.

Firſt, neither the pure and diſengaged acids, nor volatile alkalis, nor ammoniacal ſalts can be employed as fluxes in vitrification, becauſe none of theſe ſaline matters is ſufficiently fixed. Their volatility is ſo great, that they may be totally diſſipated by fire before they could act in any degree upon vitrifiable earth.

Secondly, none of the neutral ſalts with baſis of fixed alkali, containing either vitriolic acid or marine acid, can be employed as fluxes in vitrification. This proceeds, not from their want of fuſibility, or of the neceſſary degree of fixity, but from the union of the acid and the alkali; which, is ſo ſtrong, that they cannot act with ſufficient force upon other ſubſtances, and particularly upon vitrifiable earth. The ſaline matters fit for vitrification are, *fixed alkalis*, vegetable and mineral; *nitres* with baſis of fixed alkali; *ſedative ſalt*, and *borax*; *fuſible ſalt of urine*, or rather *phoſphoric acid*.

Of all ſaline matters, fixed alkalis, vegetable and mineral, are moſt frequently uſed in vitrification. Theſe alkalis are fuſible with a moderate heat; they are ſo fixed that they can reſiſt during a ſufficient time the heat of ordinary vitrifications; and they act powerfully upon flints, ſands, and other vitrifiable ſtones. The proportion of alkali to ſand, in order to make good glaſs, is, from one to two parts of the former ingredient, and two parts of the latter.

Nitre produces in vitrification nearly the ſame effects as fixed alkalis, altho' it be a neutral ſalt, the alkali and acid of which are united together nearly as they are in common ſalt, which however does not produce in vitrification ſimilar effects. The remarkable difference in this reſpect betwixt theſe two ſalts, and betwixt the nitre and the vitriolic ſalts, muſt be attributed to the great affinity of nitrous acid to the inflammable principle; which affinity is ſo ſtrong, that when nitre is expoſed to fire in veſſels not perfectly cloſe, the acid quits its alkaline baſis to unite with the phlogiſton of combuſtible matters, even though theſe be not ſenſibly in contact with it. Hence nitre expoſed during a certain time to the action of a ſtrong fire, is gradually alkaliſed, and then becomes capable of diſſolving very effectually vitrifiable earth. This alkaliſation is produced ſo much more eaſily in moſt vitrifications, that the ingredients employed generally contain ſome inflammable matter. Common ſalt cannot be alkaliſed in this manner, becauſe it cannot be decompoſed by the contact of inflammable bodies, and therefore is not uſed in vitrifications: but as vitriolic acid has a ſtrong affinity with phlogiſton, we might be inclined to think, that vitriolic ſalts with baſis of fixed alkali, which alſo are never uſed in vitrification, might perhaps be employed along with ſand or other vitrifiable matters containing a larger proportion of phlogiſton than the ingredients now commonly uſed do: but I do not know that any ſufficiently accurate experiments have been made on this ſubject.

Fixed alkalis or nitre cannot be formed into tranſparent glaſs by being melted ſingly; becauſe theſe ſalts contain too little of the earthy principle; for they form true glaſſes when they are mixed with a ſufficient quantity of this principle, as with ſands and other earthy matters : but borax, ſedative ſalt, and the fuſible ſalt of urine, may be melted without any earthy addition, into tranſparent vitreous maſſes; and hence we may conclude, that theſe ſalts contain a larger portion of the earthy principle than nitre or fixed alkali. They nevertheleſs very powerfully promote the vitrification of other ſubſtances. Theſe ſalts are not employed in the manufacture of large quantities of glaſs, becauſe they are too dear. Borax is ſometimes uſed for making ſmall quantities of ſome particular kinds of fine glaſs.

Arſenic may be enumerated among vitrifying fluxes, as it is fuſible and vitreſcible ſingly, and is alſo capable of promoting the fuſion of vitrifiable earths; for which purpoſe it is frequently employed as an ingredient in vitreous compoſitions. As arſenic partakes both of the metallic and ſaline properties, it probably acts in vitrification both as a ſalt and as a metallic earth. The quantity therefore of arſenic neceſſary to promote vitrification, is intermediate betwixt the quantities of calx of lead and of ſaline ſubſtances that are neceſſary for that purpoſe. But we muſt obſerve, that as arſenic is very volatile, a great part of it eſcapes in vapors upon the firſt application of heat, and that the quantity remaining is always uncertain. Arſenic cannot well be employed as the ſole flux for vitrifiable earth. When we intend that a certain quantity of this matter ſhould remain in the compoſition of a glaſs, one of the beſt methods that can be uſed for this purpoſe, is at the ſame time to add nitre to the ingredients of this glaſs; becauſe the arſenic uniting with the alkaline baſis of the nitre forms the neutral arſenical ſalt, in which the arſenic is conſiderably fixed. But as this neutral arſenical ſalt is eaſily decompoſed by contact of phlogiſton, therefore no calx of lead or other ſubſtance containing the inflammable principle ought to be mixed with arſenic in the compoſition of glaſs. I have found by experience that this neutral arſenical ſalt is very difficultly manageable in vitrifications, not only for the reaſon now given, but alſo from the property it has of powerfully corroding and pervading crucibles and pots. In many mixtures I have found that it quitted the vitrifiable earth with which it was mixed, and acted upon the crucible, which it penetrated and diſſolved. Theſe experiments induce me to believe, that arſenic has a greater affinity with clays than with vitrifiable earths; which I propoſe hereafter to aſcertain further.

From Mr. Pott's experiments, chemiſts know, that vitrifiable, calcareous, and argillaceous earths, each of which are ſingly unfuſible, do reciprocally promote the fuſion of each other, when mixed together nearly in equal proportions, and expoſed to a very violent heat; and that from theſe mixtures matters perfectly vitrified are formed. But as we do not know the cauſe of this ſingular fuſibility, we cannot determine whether it is produced by a phlogiſtic or by a ſaline ſubſtance, or perhaps by both.

Glaſſes that contain no other fluxing ingredient than phlogiſtic matters or metallic earths, partake of the properties of theſe metallic earths; and alſo glaſſes that contain only ſaline fluxes partake of the properties of ſalts. The latter, or ſaline glaſſes, when pure and well proportioned are leſs heavy, leſs denſe, harder, whiter, more brilliant, more brittle, than the glaſſes containing calx of lead: and glaſſes containing both ſaline and metallic fluxes do alſo partake of the properties of both theſe ſubſtances. In general, glaſſes too ſaline are ſoft, and eaſily ſuſceptible of alteration by the action of air and water; eſpecially thoſe in which alkalis prevail; which latter glaſſes are alſo liable to be attacked by acids, as we evidently ſee from the properties of the vitrified matter that is made with an exceſs of alkali, for the preparation of *liquor of flints.* Glaſſes containing too much borax and arſenic, although at firſt very beautiful, do quickly tarniſh and become opake when expoſed to air.

From what we have ſaid concerning the properties of fluxes, phlogiſtic or ſaline, we may know how to adjuſt the proportions of theſe to the ſand, or powdered flints, for the various kinds of glaſs. Thus if we require a glaſs that is denſe, fuſible, and not ſaline, one part and a half of red lead or litharge may be mixed with one part of ſand, and fuſed together. If equal parts of ſand and of calx of lead be employed, a glaſs ſomewhat leſs denſe and harder will be produced.

If a glaſs be required of very little denſity, only ſaline fluxes muſt be employed. A glaſs of this kind may be compoſed of ſix parts of ſalt of tartar, or of potaſh, or of purified ſoda, mixed with eight parts of ſand or of flints; or of four parts of any of the above-mentioned alkalis, mixed with two parts of nitre or of borax, and eight parts of vitrifiable earth. Theſe glaſſes muſt be left long in the fire for the reaſons hereafter to be mentioned.

When a cryſtal-glaſs is required which ſhall be of an intermediate quality betwixt the metallic and ſaline glaſſes, it may be made from a mixture of one part of the above-mentioned ſalts, one part of calx of lead, and two parts of ſand or other vitrifiable earth. By varying the proportions of theſe ingredients, many different kinds of glaſſes may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to its vitrifying power. Several good receipts for glaſs, and factitious cryſtal, may be found in *Neri's Art of Making Glaſs*, with *Notes by Merret and Kunckel*, to which work we refer for many intereſting particulars. We ſhall however obſerve, that the proportions of the fluxes neceſſary to produce any required kind of glaſs cannot be preciſely aſcertained, for the following reaſons.

Firſt, the ſands, flints, and other ſtones commonly employed for making of glaſs, are not all equally fuſible. Thus the quartzoſe ſand obtained by waſhing an earth found near Nevers, known to manufacturers of glaſs and of pottery by the name of *ſand of Nevers*, may be almoſt entirely melted when expoſed to a good vitrifying heat; and by a moderate heat its grains may be conſiderably rounded. I know ſome other hard ſtones, which in a violent fire are ſtill more fuſible, and convertible into an almoſt tranſparent glaſs without addition. The fuſibility of theſe vitreſcible ſtones is cauſed by ſome unknown heterogeneous matter united with them. Theſe fuſible ſands and ſtones require much leſs quantity of flux to promote their vitrification, than other ſands or vitrifiable ſtones, which are much purer, and therefore more refractory.

Secondly, although the phlogiſtic and ſaline matters employed as fluxes in vitrification are ſufficiently fixed to ſupport the degree of fire neceſſary for the fuſion of glaſs, they are nevertheleſs far from being ſo fixed as vitrifiable earth. The fire neceſſary for the perfect fuſion of glaſs, is even ſufficient to evaporate them entirely. Accordingly in glaſs-houſes where the pots are uncovered, a vapor or ſmoke continually riſes from their ſurface, which is nothing elſe than the ſaline and phlogiſtic fluxes in a ſtate of continual exhalation. Hence the longer glaſs remains melted in the fire, the harder and more difficultly fuſible it becomes, and the more it partakes of the properties of pure vitrifiable earth. Accordingly, even when a very hard glaſs is required, ſuch a quantity of flux ought to be added, as ſhall at firſt promote a perfect fuſion; and this fuſion ought to be continued a long time till a conſiderable quantity of the flux is gradually diſſipated, and till the glaſs has acquired the requiſite degree of hardneſs, provided that the fire be ſufficiently ſtrong to maintain the fuſion notwithſtanding the loſs of flux. From theſe obſervations it appears, that we cannot preciſely aſcertain the proportion of flux to vitrifiable earth, unleſs we knew the fuſibility of the ſand to be employed, and the degree of heat which can be excited in the furnace.

The ſaline fluxes, and eſpecially the fixed alkalis employed in vitrification, are generally rendered impure by a mixture of ſeveral heterogeneous matters, and eſpecially by neutral ſalts not vitrifiable, and by a certain quantity of inflammable principle. In manufactories of bottles and other common glaſs, the alkalis employed are not previouſly purified, but are even mixed with the earth of the aſhes of the burnt plants, which earth is alſo much diſpoſed to vitrification. Accordingly, to make glaſs of this kind, ſand is mixed with common wood-aſhes, ſometimes even with thoſe which have been lixiviated, together with ſome unpurified potaſh, ſoda or kelp; and from this mixture a brown, duſky, not very tranſparent glaſs is produced, which is preferred in common ſale for wine bottles to clearer and more tranſparent glaſs. But when a fine, white, and very tranſparent glaſs is required, the alkali muſt be perfectly purified from all heterogeneous matter, by lixiviation and calcination. *See the article* ALKALI (FIXED).

As a too large quantity of the inflammable principle is the chief cauſe of the colors and of the opacity of glaſs, when a perfectly colorleſs and tranſparent glaſs is required, not only the alkalis muſt be deprived of all their ſuperabundant phlogiſton, but alſo the ſands or flints employed muſt be purified from any of this principle which they may contain. The method uſed for this purpoſe is, by mixing together the due proportions of ſands and ſalts, by expoſing the mixture during a conſiderable time to a red heat, not intenſe enough to melt it. By this calcination, the phlogiſton of theſe matters is burnt and diſſipated, all color is deſtroyed, and the glaſs produced is alſo more clear and brilliant. This firſt mixture of materials of glaſs, when calcined, is called *the fritt*; and this fritt is uſed in large manufactories not only for the finer glaſs, but alſo for the common brown glaſs; not with an intention to render this latter kind of glaſs colorleſs, but becauſe during this calcination, the ſalts and earth begin to act upon each other, and to incorporate in a certain degree; by which a great part of the effervescence and ſwelling occaſioned by the reaction of theſe matters, which happen when they are at once expoſed to a melting heat, are avoided. Accordingly when matters not previouſly fritted are employed in ſmall experiments, the heat muſt be applied gradually; otherwiſe they ſo ſwell, that frequently the greateſt part of the mixture runs over the crucible.

The due degree of heat is an eſſential point in making of glaſs; it ought not only to be very ſtrong, but alſo maintained during a long time. In [illegible] manufactories, the glaſs is kept fuſed during ten or twelve hours before it is taken out of the pots. Accordingly their glaſs is always more perfect than that which is haſtily made in ſmall quantity in two or three hours. Good glaſs, although kept in fuſion in a very great heat, is not perfectly liquid. It is always ſomewhat thick, and when taken from the crucible, it may be drawn out into fine wire or threads; which ſhews that it has a certain conſiſtence and a very ſenſible tenacity when it is red-hot. It is not tranſparent, while it remains red-hot, not even when it has become perfectly hard. Another remarkable circumſtance is, that glaſs which is ſo brittle when it is cold and tranſparent, is very ductile when it is ſo heated as to be opake. We might be induced to believe, that the diſengaged fire with which the glaſs is filled when it is red-hot, produces upon it the ſame effect that phlogiſton, or combined fire, produces upon metals. The ductility of red-hot glaſs is very uſeful; for by its means all imaginable ſhapes may be given to glaſs, and numberleſs veſſels and utenſils may be eaſily formed of it

As ſoon as glaſs-veſſels have received their intended form, they muſt be cooled very gradually, otherwiſe they would have no ſolidity, and would be of little uſe, as they would be liable to be broken by the ſmalleſt ſtroke, or by a ſlight change of heat and cold. This inconvenience is prevented in glaſs-houſes by carrying the glaſs veſſels as ſoon as they are formed, and while yet red-hot, into an oven too little heated to deſtroy their form, but in which they may be very gradually cooled. This is called *annealing* the glaſs.

Notwithſtanding all the care taken in the manufactories of the finer kinds of glaſs, as cryſtal-glaſs and plate-glaſs, to make them perfectly good, they are nevertheleſs ſeldom found quite free from faults. The principal faults in glaſs are, colors, bubbles, and veins. The colors which generally hurt glaſs, eſpecially that kind which contains ſaline fluxes, are ſhades of green, olive, and blue. Theſe colors are deſtroyed by *mangancſe*, which being added in ſmall quantities, clears the glaſs, and is therefore ſometimes called by artiſts, *the ſoap of glaſs*. This effect of manganeſe cannot eaſily be explained, for it has the property of tinging glaſs with a purple color. Mr. Montamy, in his *Traité des Couleurs pour la Peinture en Email*, has a very fine and ingenious thought upon this ſubject, which is, that the manganeſe deſtroys the above-mentioned colors, by adding to theſe a purple tinge, and by the mixture producing a blackiſh-brown color; and that as blackneſs is cauſed merely by an abſorption of the rays of light, therefore the blackiſh tinge given to the glaſs by the above mixture of colors, prevents the reflection of ſo many rays, and thus renders the glaſs leſs colored than before. The cauſes of the bubbles and of the veins in all glaſs, even when moſt carefully prepared, and the methods of preventing theſe faults are little known. No reſearches have been made upon this ſubject, by any chemiſt excepting by Mr. D'Antic, whoſe experiments are publiſhed in the Memoirs of the Academy. But however intereſting theſe may be, this matter requires further examination. As the veins of glaſs, unleſs they be conſiderable, are ſeldom very perceptible in the finer kinds of glaſs when well compounded, and carefully made, they have therefore been hitherto neglected. Nevertheleſs we ought to inform thoſe who are intereſted in the progreſs of arts and ſciences, that ſince the important diſcovery of achromatic teleſcopes has been made, the correction of this fault in glaſs deſerves attention. We need only inform thoſe who would attempt this improvement of glaſs, that the object-glaſs of theſe teleſcopes is compoſed of ſeveral glaſſes of different degrees of denſity; and that the effect of this compoſition of different glaſſes is (ſuppoſing them at the ſame time to have the due curvatures), that teleſcopes may be made, which do not exhibit iriſes when looked through, which are therefore infinitely preferable to ordinary teleſcopes, and from which aſtronomy may receive much advancement.

Some great geometers have determined the denſity and the curvature that theſe object-glaſſes ought to have. But in vain have Euler, Clairaut, and D'Alembert illuſtrated this part of dioptrics by means of the moſt ſublime theory, unleſs glaſſes can be made which ſhall be capable of producing the effects required. No certain and conſtant method is yet known for making cryſtal-glaſs for this purpoſe. A celebrated Engliſh optician, Mr. Dollond, who has himſelf had a conſiderable ſhare in the diſcovery of theſe new teleſcopes, does indeed make them very good (*p*). But our opticians, who procure from England the ſame glaſs that is employed by the Engliſh opticians, affirm that this glaſs is very faulty; and that amongſt a large quantity, ſome pieces only can be found fit for the purpoſe: hence we find that it is not conſtantly made good in the Engliſh glaſs-houſes.

A certain method therefore of making ſuch a cryſtal glaſs as is required, ſtill remains to be diſcovered. Two kinds of glaſs are required for the object-glaſs of achromatic teleſcopes. One of theſe is a light cryſtal-glaſs, made with ſaline fluxes, like the French mirror-glaſs.

Good pieces of this kind of glaſs may be eaſily found. The other kind of glaſs is a denſer cryſtal-glaſs, and therefore contains ſome calx of lead in its compoſition. Such is the Engliſh flint-glaſs. The denſity of this glaſs ought to be ſuch, that a cubic inch ſhall weigh fourteen hundred grains. A perfect

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(*p*) The indiſtinctneſs of the images ſeen through common teleſcopes proceeds chiefly from this cauſe, that ſome of the colored rays of light are refracted more in paſſing through glaſs, or any refracting medium, than the others, and do therefore produce priſmatic colors. The late ingenious Mr. Dollond found, that this difference of refrangibility of the colored rays was much greater when the rays paſſed through ſome kinds of glaſs, as crown-glaſs, than through others, as flint-glaſs. By adding therefore to the convex object lens of teleſcopes (which was made of crown-glaſs) a concave lens made of flint-glaſs, the curvature of which was not ſufficient to deſtroy the whole convergency of rays of light produced by the convex lens, he counteracted the error proceeding from the different refraction of the colored rays in paſſing through the convex lens, and, by thus uniting theſe ſeveral rays, formed one diſtinct image. This power of different kinds of glaſs, by which they refract differently the colored rays is not proportionable to the denſity of the glaſs; although calx of lead added to glaſs ſingularly encreaſes this difference of refraction. The author of the Dictionary ſays, that Mr. Dollond had a great ſhare in this diſcovery. He was the firſt perſon who attempted or who executed this improvement. We may indeed obſerve, that long before, in the year 1713, Dr. David Gregory, the celebrated Profeſſor of Aſtronomy at Oxford, did ſuggeſt, (in his *Catoptricæ et Dioptricæ Sphæricæ Elementa*) that by compounding the object lens of a dioptric teleſcope of ſeveral media of different refractive powers, the image might be rendered more diſtinct, in the ſame manner (ſays he) as it is done by the compounded media of the eyes of animals.

glaſs of this kind cannot be obtained without great difficulty. I have been aſſured by ſome intelligent perſons, who have conſidered this ſubject of achromatic teleſcopes, that the qualities eſſentially requiſite in this glaſs were, that it ſhould be very tranſparent, and perfectly free from veins, to which it is very liable; and that a ſlight tinge of yellow and even a few bubbles were not very injurious. I have made many experiments to obtain a cryſtal glaſs free from veins, but have met with great difficulties. The veins are undulated, like thoſe which appear when two liquors of different denſities, as water and ſpirit of wine, are added together, and before they are well mixed. This appearance ſhews, that ſomething ſimilar happens in the making of glaſs. I endeavored to correct this fault by a very careful mixture, and by a compleat fuſion. But I confeſs, that although I have expoſed theſe glaſſes to very violent and long continued fires, and have ſeveral times pulveriſed and ground them, and repeated the fuſion, I have not been able to procure any perfectly free from veins. I have been prevented by other neceſſary occupations from continuing my experiments on this ſubject. But although thoſe which I have made ſufficiently ſhew the difficulty of making glaſs of the required denſity, and which ſhall be perfectly free from veins, this difficulty nevertheleſs does not appear unſurmountable; and I do not doubt but that by patiently proſecuting this inquiry, we may arrive at the deſired ſucceſs.

We ſhall obſerve, in concluding this article, that ſeveral cauſes leſſen or entirely prevent the tranſparency of glaſs, which is one of its moſt neceſſary qualities. As we cannot melt vitrifiable earth into tranſparent maſſes but by means of fluxes, and a ſufficiently ſtrong and long-continued heat, therefore when the vitreous mixture contains too little flux, or is expoſed to too little heat, ſome parts of the vitrifiable earth cannot be entirely fuſed, and therefore impair more or leſs, according to their quantity, the tranſparency of the glaſs. The ſame fault may be perceived in glaſs, when it contains ſome earthy matter not ſuſceptible of the action of fluxes, as vitrifiable earth is; ſuch as, for inſtance, moſt metallic earths that are too much dephlogiſticated, particularly the earth of tin. Accordingly, theſe earths are employed to make opake or ſemi-tranſparent glaſſes, as enamels, artificial opals, and other ſuch ſtones. Another remark may be made concerning the tranſparency of ſome kinds of glaſs, that is deſtructible by a too long expoſure to violent heat. As all fluxes, phlogiſtic or ſaline, are much leſs fixed than vitrifiable earth; and as ſome fluxes are leſs fixed than others, or leſs capable of becoming fixed by being mixed with vitrifiable earth; the cauſe therefore of the loſs of tranſparency which ſome glaſſes ſuffer by a too violent fire, is, that a part of their flux is diſſipated, ſo that theſe glaſſes are decompoſed, and that they contain ſo much earth that their flux is incapable of keeping them compleatly fuſed. I have obſerved that glaſſes formed by a mixture of argillaceous, and gypſeous or calcareous earths are more liable than any others to this loſs of tranſparency. *See* ALKALI, EARTH, FURNACES, *and ſeveral other articles relating to vitrification.*

DCCLIX. VITRIOL. This name is particularly applied to three neutral vitriolic ſalts with metallic baſes. Theſe ſalts are, 1. The combination of vitriolic acid with iron, called *martial vitriol*, *Engliſh vitriol*, *green vitriol*, or *green copperas*. 2. The ſalt reſulting from the union of the ſame acid with copper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, or *blue copperas*. 3.

3. The ſalt compoſed of vitriolic acid with zinc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *Goſlar vitriol*.

We have obſerved under the articles *vitriolic acid* and *ſalts*, that the name *vitriol* ought to be applied to all vitriolic ſalts with metallic baſis. Thus, for inſtance, the ſalt compoſed of vitriolic acid and gold may be called *vitriol of gold*; and the ſalt formed by the union of this acid with ſilver may be called *vitriol of ſilver*, or *lunar vitriol*. Perhaps all vitriolic ſalts might be conveniently comprehended under the general name *vitriol*. The properties of vitriolic ſalts are mentioned at the articles, Acid (Vitriolic), Alkalis, Earth (Calcareous), Salts, Selenites, Gypsum, Alabaster, Spar, Smelting *of* Ores, *and of the ſeveral metallic ſubſtances*.

DCCXX. UMBER. (q)

DCCXXI. VOLATILITY. Volatility is a property that many bodies have of being reduced into light vapors, which exhale when they are expoſed to the action of fire. This quality is oppoſed to *fixity*. The cauſe of it is the greater or leſs *dilatability* which bodies have when expoſed to fire. Perhaps every body is, rigorouſly ſpeaking, volatile: but as there are ſome the volatility of which can be only rendered ſenſible by the action of a fire much more violent than any which we can produce, we conſider theſe bodies as being fixed, or not volatile. *See* Fire *and* Fixity.

DCCXXII. URINE. As urine is an excrementitious animal liquor, it contains only ſuch principles as are uſeleſs or hurtful to the animal economy; and is accordingly found to be nothing but a lixivium of different ſaline ſubſtances, which cannot enter into the compoſition of an animal body, together with a quantity, not very conſiderable, of a ſaponaceous, extractive, and very putreſcent matter. In urine we find none of the gelatinous ſubſtance that is contained ſo copiouſly in other animal liquors that are not excrementitious; for this gelatinous ſubſtance, as we have ſaid under the article Jelly, is the principal conſtituent, nutritive, and reparative part of animal bodies, and could not therefore without ſome conſiderable fault or diſorder in the animal economy be rejected with any excrementitious matter. The urine of healthy animals is therefore nothing but a ſerous ſaline liquor, that may be entirely evaporated, without ſhewing any gelatinous matter.

The freſh urine of healthy animals is tranſparent, and ſomething yellowiſh or citron-colored, has a ſlight ſmell, a ſaline nauſeous taſte, and does not change the color of ſyrup of violets to a red or to a green: but this liquor varies conſiderably when the animal economy, and eſpecially the digeſtive organs are diſturbed. Accordingly, phyſicians carefully obſerve the urine of their patients; but although they often receive much aſſiſtance from ſuch obſervation, it is a dangerous error that quacks lead many ignorant perſons into, to believe, that by the mere inſpection of urine all diſeaſes may be diſcovered.

(q) Umber. Umber is a very light, duſky-colored earth, which is ſomewhat inflammable, and emits a ſtrong ſmell when it is burnt. By calcination it is changed, according to Wallerius, to a white earth, and, according to Linnæus, to a red earth; whence the latter author conjectures that it contains ſome iron. It ſeems not to have been much examined.

Phyſicians, who have paſſed their lives in an attentive obſervation of the ſigns of diſeaſes, are too ſenſible of the inſufficiency of every aid to decide certainly concerning the nature of many diſeaſes. But this reflection ought to be a motive to inquire into the various changes that urine undergoes in different ſtates of the body, more accurately than has been hitherto done, eſpecially as the improvements daily made in chemiſtry may give us hopes of throwing more and more light upon this and other intereſting ſubjects.

The qualities of urine are very apt to vary conſiderably, even without any very perceptible derangement of the animal economy. For inſtance, it is ſometimes much more copious than at other times. This difference of the quantity of urine has been obſerved to depend much on the quantity of perſpiration and of ſweat that have been exſuded at the ſame time; for the nature of theſe fluids is very ſimilar to that of urine. Generally, when the urine is in ſmall quantity, it is deeper colored; and reciprocally.

The urine of perſons afflicted with hyſterical and melancholical ſpaſms is frequently copious, limpid, and purely watery or ſerous, without color or ſmell. This urine is called *crude urine.* Theſe ſame perſons do alſo frequently diſcharge urine in ſmall quantity, that is high-colored, that has a ſtrong ſmell, and that quickly becomes turbid when expoſed to cold. We may obſerve, that the ſediment which renders this urine turbid may be again rediſſolved by more freſh and warm urine, and is therefore of a ſaline nature.

Certain odoriferous ſubſtances, taken internally, as turpentine, aſparagus, and others, are well known to communicate quickly their ſmell to urine, even in perfect health: but I have alſo ſeen perſons ſubject to pains of the head and to bad digeſtion, proceeding from a melancholic or hyſterical temperament, who diſcharged urine, in which I could evidently perceive the ſmell of coffee, ſpices, onions, fruits, roots, and even of broth, and other aliments. The urine of theſe perſons was habitually acid, reddened ſyrup of violets and blue paper, when it was recent, and eſpecially after eating fruits and roots, or drinking even a very ſmall quantity of wine.

From theſe two latter obſervations we may perceive, that urine depends much on the ſtate of digeſtion, the faults of which may therefore be diſcovered by examining that liquor.

Urine is ſtrongly diſpoſed to putrefaction. In ten or twelve hours, when the weather is warm, it acquires a ſtrong ſmell; and in great heats, this ſmell may be perceived in five or ſix hours. The beginning of the putrefaction of this liquor may be perceived by a putrid, diſagreeable, but not pungent ſmell. The ſmell afterwards becomes pungent, and diſcovers a volatile alkali, which is very copiouſly diſengaged in the putrefaction of this liquor. Although the diſagreeable ſmell that is perceived at firſt in urine beginning to putrefy has not the pungency of volatile alkali, it neverthelefs ſeems to be produced by this ſalt; for by mixing any acid with urine in this ſtate, its fetid ſmell is immediately deſtroyed. By the ſame means alſo the ſmell of veſſels in which urine has been contained may be deſtroyed. On the contrary, by mixing ſome fixed alkali or quicklime with freſh urine, a pungent ſmell of volatile alkali and of putrid urine is inſtantly produced. As in ſo ſhort a time no real putrefaction can happen, we muſt attribute the diſcharge of volatile alkali in this experiment to a decompoſition of a ſal ammoniac, which is contained in the freſheſt urine, as we ſhall ſoon ſhew.

If the freſh urine of a healthy perſon be diſtilled in cloſe veſſels, nothing is obtained from it with the heat of boiling water, but a pure phlegm with a ſlightly nauſeous ſmell. This phlegm is generally $\frac{7}{8}$ parts or more of the whole urine; but the quantity of this and of the other principles of urine are very various.

As nothing but phlegm is ſeparated at firſt in this diſtillation, when therefore urine is to be analyſed, the operation may be accelerated and ſimplified by evaporating it over the fire in an open veſſel. We may then obſerve, that while the phlegm of the urine is evaporated, the remaining liquor becomes turbid, and depoſites a certain quantity of matter which is almoſt entirely earthy. The quantity of this earth varies alſo according to the nature of the urine. It deſerves a particular examination. The obſervations of Mr. Heriſſant, Phyſician of the Faculty of Paris, and Member of the Academy of Sciences, concerning the urine of ſeveral perſons afflicted with diſeaſes in which the bones were affected and waſted (*See Memoirs of the Academy for the year* 1758); and thoſe alſo of Mr. Morand, of the ſame Faculty, and Member of the ſame Academy, concerning the urine of a woman whoſe bones were entirely ſoftened by the loſs of their earthy matter, which was found to contain a conſiderable quantity of earthy ſediment; ſhew, that the earthy ſediment of urine, which is firſt depoſited by evaporation, is partly at leaſt of the ſame kind as the earth of bones; and that in a healthy ſtate, nature throws off by the urinary paſſages all the earthy matter that is not required for the encreaſe or reparation of the bones. This earthy ſediment appears alſo in putrid urine.

While the urine evaporates, the remaining part of it acquires a more and more deep brown color, by the approximation of the ſaponaceous extractive parts which it contains. When, by evaporation, it has acquired the conſiſtence of a clear ſyrup, or of freſh cream of milk, it ought to be put in a cool place, that the ſeveral neutral ſalts which it contains may be cryſtallized. The firſt cryſtals that are obtained are a particular kind of ſalt known to chemiſts by the names, *native* or *eſſential ſalt of urine*, *fuſible ſalt of urine*, *phoſphoric ſalt*, and *microcoſmic ſalt*. This ſalt contains the acid proper for making phoſphorus. Some part of this ſalt has a baſis of volatile alkali, and is therefore a kind of ammoniacal ſalt; and the reſt has a baſis of fixed alkali. *See* SALT (FUSIBLE) *of* URINE, *and* PHOSPHORUS *of* KUNCKEL. When the urine contains any ſalts that are more cryſtallizable or leſs ſoluble than the fuſible ſalt, as it frequently does, ſuch as ſelenites, vitriolated tartar, and others, theſe are firſt cryſtallized, eſpecially if they be in conſiderable quantity. *See* CRYSTALLIZATION.

By alternately evaporating and cooling the liquor, the other leſs cryſtallizable ſalts, ſuch as common ſalt, a great quantity of which urine generally contains, may be ſeparated. In the urine of different animals all the neutral ſalts are generally found which they have taken, either along with their aliments or otherwiſe; becauſe theſe ſalts, not being uſeful in the compoſition of animal matters, after having circulated ſome time in the blood-veſſels, are carried off, unchanged, along with the urine.

After all the neutral ſalts have been obtained from urine, nothing remains but a brown, ſaponaceous, extractive matter, which forms a kind of mother-water. This matter yields, with a naked and graduated fire, a conſiderable quantity of volatile alkali, both fluid and concrete, together with ſome fetid animal oil. With the utmoſt violence of fire, a ſmall quantity of phoſphorus may alſo be obtained; and a little common ſalt may be ſeparated from the reſiduous coal. This phoſphorus is produced by a little fuſible ſalt which was not ſeparated by cryſtallization, but remained, together with the above-mentioned ſmall quantity of common ſalt, diſſolved in the liquor.

From this analyſis of urine we may perceive, that it is compoſed of a large portion of pure water, in which is diſſolved a conſiderable quantity of earthy matter, that forms the ſediment of urine; of two phoſphoric ſalts, one of which is ammoniacal, and the other has a baſis of fixed alkali; of common ſalt; and, laſtly, of a ſaline, ſaponaceous matter, which contains a combined oil. In urine no gelatinous matter nor uncombined oil are found.

Such is the ſtate of our preſent knowledge concerning the nature and principles of urine. It certainly is capable of receiving much addition from future inquiries, by which medicine might be much improved; but we muſt, at the ſame time, confeſs, that we cannot receive all the knowledge we wiſh upon this ſubject without very long and laborious operations. The moſt important point to be known is the compoſition and proportions of the ſeveral conſtituent parts of urine: but, as we have already remarked, theſe are very variable, according to the ſtate of health or of ſickneſs, to the differences of conſtitutions, aliments, exerciſes, diſeaſes, medicines, and perhaps even to the variations of the atmoſphere. A knowledge of the differences of the urine in all theſe ſeveral circumſtances is very important, but can only be acquired by a long and zealous obſervation of thoſe phyſicians who are inſtructed in the ſeveral ſciences relative to their profeſſion.

W.

DCCXXIII. **WAND (DIVINING).** The divining wand is an inſtrument, by means of which many perſons have formerly pretended, and ſome do now pretend, to diſcover under what parts of the earth metals, treaſures, ores, water, ſalt, &c. lie hid, without digging the ground. They ſay, this diſcovery may be made by a perſon holding the wand horizontally, and by walking along in places where theſe matters are expected; and that when he arrives at a place under which any of the above-mentioned matters lie, the wand will be forcibly inclined towards that place: but that this experiment ſhould ſucceed, much faith ſeems to be required in the perſon who holds the wand, or rather in the ſpectators. We may eaſily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many intereſting particulars are found concerning mines, juſtly derides theſe ſuperſtitious practices, and denies, from his own experience, the truth of the aſſertions concerning them. He ſeems, however, to have ſome faith in ſympathies, and propoſes even new divining wands of his own invention; the effects of which, though more dependant on phyſical cauſes, are not however more certain. He believes, for inſtance, that a wand, one end of which ſhould be made of ſal gem, and the other of wood, being ſuſpended and balanced above a mine of ſalt, would be inclined towards the ground; and he ſupports his opinion by an experiment. This experiment conſiſts in evaporating over the fire a ſolution of ſal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemiſtry to diſcover, that the wand would have inclined in the ſame manner if Father Kircher had evaporated pure water inſtead of a ſolution of ſal gem; becauſe the water would have equally well attached itſelf to the ſaline end of the wand; conſequently this experiment proves nothing.

The ſame author propoſes alſo to diſcover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and, 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſt upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no ſympathy with water, over a ſubterranean water, and that he obſerved the end of the wand incline towards the earth.

DCCXXIV. WATER. Water, perfectly pure, (for of ſuch only we treat in this article) is a tranſparent body, without color, without ſmell, and without taſte.

Water is very volatile, and ſo very fuſible, that it is conſtantly liquid with a leſs degree of heat than is requiſite for vegetation: hence it is generally conſidered as a liquid. But when it is expoſed to a leſs degree of heat, it becomes ſolid, like all other bodies naturally ſolid, which reſume their ſolidity when they are no longer expoſed to a heat ſufficient to keep them in fuſion.

When water, that is expoſed to a degree of cold ſufficient to render it ſolid, paſſes from a fluid to a ſolid ſtate, this change is called the *congelation* or *freezing of water*; and the water thus rendered ſolid is called *ice*.

When water is frozen with all the circumſtances neceſſary for the free arrangement of the integrant particles of bodies (which circumſtances are explained under the article CRYSTALLIZATION), it aſſumes determinate and regular forms. M. de Mairan, in his excellent Treatiſe on Ice, has determined, that theſe regularly formed maſſes of frozen water are like needles croſſing each other, or rather infixed into each other, ſo as always to form two angles, one of which is equal to ſixty degrees, and the other equal to a hundred and twenty degrees.

This regularity in the congelation or cryſtallization of water ſhews, that it is a body not much compounded. We ſhall ſoon ſee that it is one of the ſimpleſt of all known bodies.

Water is not compreſſible. This truth is aſcertained by a famous experiment, which conſiſts in including water in a hollow ſphere of metal hermetically cloſed, and in expoſing this ſphere to a very ſtrong compreſſion, by which means the water is forced through the pores of this metallic ſphere rather than ſuffer any compreſſion. (r)

(r) The validity of the inferences drawn from this experiment, called the *Florentine experiment*, has been juſtly queſtioned. An ingenious philoſopher, Mr. Canton, has proved, by experiments ſhewn to the Royal Society, that water is actually compreſſed by the weight of the atmoſphere. The diminution of ſize that water ſuffers when it paſſes from a greater to a leſs degree of heat, till it begins to freeze, ſufficiently ſhews, that the integrant parts of this fluid are, like thoſe of all other known ſubſtances, capable of approximation.

The ſpecific gravity of water, compared with that of air in a temperature intermediate betwixt the greateſt ſummer heats and the greateſt cold of winter, has been determined by the beſt experimental philoſophers to be nearly as 850 to 1; that is to ſay, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have ſaid above, that water is a very volatile body. It is entirely reduced into vapors and diſſipated, when it is expoſed to the fire, and is not confined.

When water is heated in an open veſſel, and is unconfined, it has been obſerved to acquire no more than a certain determinate degree of heat, whatever be the intenſity of the fire to which it is expoſed; which greateſt degree of heat is that which it has when it boils quickly. This degree of heat, and alſo that degree at which water begins to freeze, are fixed and determinate, and are therefore very uſeful in many chemical and phyſical experiments. By means of theſe fixed points of heat, we have been enabled to conſtruct thermometers, which may always be compared one with another; and we have alſo been enabled to apply preciſe and determinate degrees of heat, which are neceſſary in many chemical operations. *See* BATH (WATER).

Some philoſophers have ſaid, that the property which water and ſome other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction cauſed by this degree of heat, by which means the fire penetrates them freely and without any reſiſtance. *See* FIRE. But this opinion is erroneous. The cauſe of this phenomenon evidently is, that water being volatile, is reduced into vapors which are conſtantly exhaled and removed from the fire, the action of which they elude as ſoon as they ſuffer a certain degree of heat, as may be proved by the following conſiderations.

Firſt, none but volatile bodies have this property; bodies abſolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the leſs heat it can acquire, and reciprocally; or, to ſpeak geometrically, the degrees of heat which bodies expoſed to the action of fire, and unconfined, can acquire, are inverſely as their volatility, and conſequently directly as their fixity.

Secondly, when water and all volatile bodies are expoſed to the action of fire, and ſo confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more conſiderable, is indeterminate, or rather proportionable to the force with which they are confined, and prevented from evaporating.

We have an obvious example of this in the effects of *Papin's Digeſter.* Water being confined in this veſſel ſo that it cannot evaporate, is capable of acquiring a degree of heat much greater than that with which it boils in open air, and even ſufficient to make it red hot.

Upon this ſubject we muſt obſerve, that when water, or other volatile bodies, are thus expoſed to a greater degree of heat than is ſuited to their volatility, they are in a violent ſtate; and are therefore apt to break any veſſels that confine them, with an exploſion ſo much more violent, as they are more ſtrongly compreſſed, and are expoſed to a more violent and more ſuddenly applied heat.

Hence we may conceive why water expoſed to heat too ſuddenly to allow it to evaporate gradually occaſions terrible exploſions; as, for inſtance, when water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moiſt veſſel.

We ought to obſerve upon the ſubject of theſe exploſions, that they only happen when the volatile bodies are in an aggregate ſtate, or are combined with other volatile bodies; for the moſt volatile ſubſtances, when combined with fixed bodies, may be expoſed to the moſt violent heat without producing theſe effects. Thus water, when combined with quicklime, with fixed alkali, and other ſalts, may be ſuddenly expoſed to a red-heat without danger of exploſion.

Water ſeems to be unalterable and indeſtructible: at leaſt, no experiment is hitherto known from which we may infer that water may be decompoſed. With whatever ſubſtances it may be combined, when ſeparated from theſe and ſufficiently purified, it is always found to be the ſame as before. When it is diſtilled ſingly, or mixed with ſome other ſubſtance, its nature and eſſential properties ſtill remain unchanged.

Some philoſophers, as Boyle, and eſpecially Mr. Margraaf, having very frequently diſtilled the ſame water, obtained at each operation a ſmall portion of earth; but the water which was diſtilled remained always eſſentially the ſame. The ſmall quantity of earth ſeparated from the water ought to be conſidered as extraneous to it.

The famous experiment of Van Helmont, which has ſince his time been more carefully repeated by others, and which conſiſts in making trees and plants grow merely by means of water, does not prove, as ſome have ſuppoſed, that pure water is convertible into earth, ſalts, oil, and the other principles of vegetables; becauſe water not only contains a ſmall quantity of earth mixed with it, but alſo the air alone is the vehicle of a conſiderable quantity of theſe principles, or of ſuch as are capable of producing them.

Water therefore appears to be a body ſimple and unalterable: at leaſt, chemiſts, not having any means of decompoſing it, may conſider it as ſuch. They have accordingly claſſed it amongſt the *elements* or primary principles. *See* ELEMENTS *and* PRINCIPLE.

Many experiments and chemical analyſes ſhew, that water enters as a principle in the combination of many compound bodies, ſuch as all ſaline and oily ſubſtances (*See* SALT *and* OIL); and conſequently that it is a part of all vegetable and animal matters, and of all the ſaline parts of minerals. Several ſtones even, in which no ſaline matter appears, as calcareous ſtones, contain a certain quantity of water, which ſeems to be in a ſtate of combination. *See* EARTH (CALCAREOUS) *and* QUICKLIME. But hitherto no experiment ſhews, that water enters as a principle into the combination of *metallic matters*, or even into that of *vitreſcible ſtones*. *See theſe words.*

Water diſſolves many bodies. It ſeems to be capable of diſſolving a certain quantity of air; for all natural water being placed under an exhauſted receiver emits many air-bubbles; and, according to Mr. Muſſchenbroek, the water from which air has been thus ſeparated, is capable of reſuming the ſame quantity of air; that is to ſay, if a ſmall quantity of air be introduced into this water, it will not form a bubble, as it would with water already ſaturated with air, but incorporates with the water, and entirely diſappears.

Water ſeems alſo capable of diſſolving a ſmall quantity of calcareous earth; for the moſt limpid, clear water being diſtilled, always depoſites ſome part of this earth. Some very limpid ſpring waters contain ſo much calcareous earth, that they depoſite a ſediment which encruſts any bodies that happen to be immerſed in them. Theſe waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all thoſe which form incruſtations, petrefactions, and ſtalactites. This earth does not ſeem to adhere very ſtrongly to the parts of water, eſpecially when it is in conſiderable quantity. It ſeems to be in an intermediate ſtate betwixt that of ſimple mixture and of perfect combination with the water.

Metallic matters, excepting the perfect metals, are acted upon by water, but eſpecially by the vapor of water, together with the concurrence of air. It converts their ſurfaces into ruſt, and deprives them of part of their inflammable principle. It does not appear to be diſpoſed to unite with the principle of inflammability; for all the bodies that are abundantly furniſhed with this principle reſiſt the action of water, unleſs they have alſo ſome other principle that may ſerve as an intermediate ſubſtance for this union.

But, of all known bodies, ſaline ſubſtances are moſt eaſily and copiouſly ſoluble in water. A ſtrong affinity is obſervable between this element and all ſaline ſubſtances; ſo that we may ſay in general, that all ſalts are ſoluble in water; that every body truly ſoluble in water is of a ſaline nature; and that no other body can be diſſolved in water but by means of a ſaline ſubſtance. *See* SALTS.

Spirit of wine, and all ardent ſpirits of the ſame kind, may be diſſolved in water in all proportions. *See* SPIRIT (ARDENT).

The ſpiritus rector of vegetable and animal ſubſtances, and moſt of the very thin and very volatile fluids, called *gas*, are ſoluble in water. *See theſe words.*

Ethereal liquors, as vitriolic, nitrous, marine, and acetous ethers, are ſoluble in water, but only in certain proportions. *See* ETHER.

Water diſſolves the moſt ſubtle and volatile part of any oils, as Mr. Beaumé has obſerved. *See* OILS.

Compounds, formed of any oily matters united with ſaline matters, (to which compounds we ought to give the general name of *ſoap*, or *ſaponaceous ſubſtance*) are ſoluble in water, ſo much more eaſily and copiouſly as their ſaline principle is in greater quantity, and more diſengaged or unfolded. *See* SOAP.

Laſtly, water is the proper ſolvent of all mucilaginous, gummy, and gelatinous matters; which matters are compoſed of ſaline, oily, and earthy principles. *See* GUM.

We may eaſily perceive from what has been ſaid concerning the properties of water, that it muſt be very uſeful in many chemical operations: but as it diſſolves ſo many bodies, it can ſeldom be found naturally free from heterogeneous matter, or perfectly pure. The waters of rivers and of ſprings, however limpid they may be, always contain a certain quantity of earth, which is in the intermediate ſtate above-mentioned, between a ſimple interpoſition of parts, and a true ſolution. The beſt waters of this kind are thoſe which flow through ſands, gritt-ſtone, and other vitrifiable matters; becauſe vitrifiable earth is leaſt capable of being attacked by water.

The waters of many ſprings and rivers contain more or leſs of a gypſeous or ſelenitic ſubſtance really diſſolved; for as water is capable of diſſolving theſe matters, and often flows through grounds containing them, it muſt diſſolve a certain quantity of them, and even as much as ſaturates it. Waters impregnated with ſelenites are unfit for chemical operations, for being drank, for diſſolving ſoap, or for boiling leguminous vegetables. They are a kind of *mineral waters*, and are called *crude* or *hard waters*. *See theſe words.*

Rain or ſnow-waters, properly collected, that is, not in ſtormy weather, after it has already rained or ſnowed ſome time, in open air, and far from the habitations of men, and received in earthen-ware veſſels, are the beſt and the pureſt of all native waters. They are ſufficiently pure for moſt chemical operations, becauſe they have been purified by a kind of natural diſtillation: but for greater exactneſs, and becauſe theſe waters are not always procurable, diſtilled water is generally employed in chemical operations. *See* WATER (DISTILLED).

(*s*) Native water is ſeldom, if ever, found perfectly pure. The *waters* that *flow within*, or *upon the ſurface of*, *the earth* contain various earthy, ſaline, metallic, vegetable or animal particles, according to the ſubſtances over or through which they paſs. *Rain* and *ſnow-waters* are much purer than thoſe, although they alſo contain whatever floats in the air, or has been exhaled along with the watery vapors. Mr. Margraaf has very accurately analyſed ſome rain and ſnow-waters, and found that they contained a calcareous earth united with nitrous and marine acids, the rain poſſeſſing more of the former, and the ſnow more of the latter acid, together with ſome mucilaginous, oily, and ferruginous particles. The quantity of calcareous earth ſeparated, by adding a fixed alkali, from a hundred meaſures of water, each of which contained 36 ounces, was 132 grains; and the quantity ſeparated by the ſame means from an equal quantity of ſnow-water was 72 grains.

The *purity of water* may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the ſubſtances uſually diſſolved in water, fixable and atmoſpherical air excepted, are heavier than water, but alſo the ſpecific gravity of a ſolution of any of theſe ſubſtances in water is greater than the intermediate ſpecific gravity of the water and of that ſubſtance. We muſt nevertheleſs obſerve, that as fixable and atmoſpherical airs are frequently contained in water, they render it leſs heavy than it would otherwiſe be. Hence Bath, and other waters containing much fixable air, are lighter than diſtilled water, although the former contain ſaline, metallic, and earthy ſubſtances.

2. Pure water is more fluid than water that is not pure: hence it is ſaid to occaſion a louder ſound when poured from one veſſel into another.

3. It has no color, ſmell, or taſte.

4. It wets more eaſily than the waters containing metallic and earthy ſalts, called *hard waters*, and feels ſofter when touched.

5. Soap, or a ſolution of ſoap in ſpirit of wine, mixes eaſily and perfectly with it.

6. It is not rendered turbid by adding to it a ſolution of gold in aqua regia, or a ſolution of ſilver, or of lead, or of mercury in nitrous acid, or a ſolution of ſugar of lead in water.

Boerhaave, the author of this Dictionary, and other chemiſts, maintain, that pure water is unalterable; and others, as Borichius, Boyle, Wallerius, that it may be decompoſed or reſolved into other principles, eſpecially into earth.

Boyle relates, that one ounce of water, diſtilled carefully in glaſs-veſſels two hundred times, yielded ſix drams of a white, light, inſipid earth, fixed in the fire, and indiſſoluble in water. Boerhaave attributed the earth obtained by diſtillation of water to duſt floating in laboratories. Other chemiſts have made experiments to aſcertain the truth of that of Mr. Boyle. Liedenfroſt found, that when pure diſtilled water is diſſipated or evaporated by throwing it into a red-hot iron ſpoon, he always obtained a quantity of earth. Wallerius obtained a ſcruple and a half of fine white earth by triturating during two hours a dram of diſtilled water.

DCCXXV. WATERS (AROMATIC). Thoſe are called aromatic waters that are impregnated by diſtillation with the ſpiritus rector, or odoriferous principle of aromatic matters. *See* WATERS (DISTILLED).

This earth, he ſays, is ſoluble in acids, is convertible into a hard maſs by a red-heat, which maſs is unſoluble by acids, and is vitrifiable into a white tranſparent glaſs by a more violent heat. He found alſo, that a large quantity of earth is depoſited from boiling water with a ſtrong, then with a gentle fire. *See the Swediſh Memoirs for the year* 1760. Mr. Margraaf has made experiments with his accuſtomed accuracy, from which it appears, that, by diſtillation, and alſo by evaporation with the heat of the ſun, of rain water, the purity of which had been previouſly aſcertained by thirteen diſtillations, he obtained a white, light, ſhining earth. This earth could not be vitrified with the heat requiſite for the fuſion of ordinary glaſs; but by a more violent and longer continued fire it was melted into a yellow-greyiſh maſs. He found, that about half of this earth was ſoluble in nitrous acid, and that the other half was not fuſible by fire; but that, by addition of half its quantity of ſalt of tartar, it was convertible into a tranſparent glaſs. The part of the earth that was diſſolved in nitrous acid was afterwards precipitated from that acid by vitriolic acid, with which it formed a ſelenites; and hence Mr. Margraaf infers, that it is a true calcareous earth. He does not determine the claſs of earths to which the unſoluble part of the earth thus obtained by diſtilling water ought to be referred. Mr. Margraaf obſerves, that earth is more copiouſly depoſited from water boiling with a ſtrong than with a gentle heat. The quantity of earth that he obtained, in one experiment, from 72 ounces of diſtilled water, by twelve diſtillations, was nine or ten grains.

Mr. Eller relates an account of a more extraordinary alteration produced upon water, by which other principles were formed. He encloſed ſome diſtilled water in a glaſs phial, which he then hermetically ſealed, and expoſed during ſome weeks in ſummer to the rays of the ſun. At the end of this time he perceived that it was become turbid, and covered with a ſcum or pellicle. By diſtillation he obtained from this water a reddiſh oil, and ſome acid fumes. That ſo extraordinary an alteration can be produced upon pure water by the rays of the ſun, cannot be admitted till the experiment has been carefully repeated with the ſame ſucceſs.

To this article we ſhall ſubjoin three tables of different authors, ſhewing what quantity of each ſalt is ſoluble in a given quantity of water; and alſo an account of ſome experiments made by Mr. Eller, to ſhew how much of certain ſalts may be diſſolved in given quantities of water ſaturated previouſly with other ſalts.

The following table ſhews the quantities of the ſaline ſubſtances that could be diſſolved in an ounce of water, with the heat of 50° of Fahrenheit's ſcale, according to experiments made by Mr. Spielman. *Inſtit. Chemiæ, p.* 48.

	Grains
Terra foliata tartari	470
Salt of Sedlitz	384
Epſom ſalt	324
Salt of tartar	240
Vegetable ſalt	212
White vitriol	210
Sal gem	200
Salt of ſoda	200
Sal ammoniac	176
Common ſalt	170
Salt of Glauber	168
Salt of Lorraine	168
Salt of Sylvius	160
Salt of Seignette	137
Blue vitriol	124
Green vitriol	80
Purified nitre	60
Salt polychreſt of Glaſer	40
Vitriolated tartar	30
Sublimate mercury	30
Borax	20
Alum	14
Volatile ſalt of amber	5
Arſenic	5
Crude tartar	4
Cream of tartar	3

DCCXXVI. WATER (DISTILLED). Moſt natural waters contain ſome heterogeneous ſubſtances that render them impure; and as water exceedingly pure is required for many chemical operations, it muſt be therefore purified for theſe purpoſes by diſtillation. Water may be diſtilled in the following manner:

The following table is copied from Mr. Muſchenbroek. The eight firſt experiments were made by Boerhaave, and the reſt by Muſchenbroek, with a heat of 38°.

Sea-ſalt,	oz. 2.	were diſſolved in	oz. 6. and dr. 3.	of pure water.
Sal gem,	oz. 1.	———	oz. 3. and dr. 2.	———
Sal ammoniac,	oz. 1.	———	oz. 3. and dr. 2.	———
Nitre,	dr. 9.	———	oz. 6.	———
Borax,	dr. 4.	———	oz. 10.	———
Alum,	oz. 1.	———	oz. 14.	———
Epſom ſalt,	oz. 1.	———	oz. 1. and dr. 2.	———
Green vitriol,	dr. 1½	———	oz. 3.	———
Arſenic,	oz. 1.	———	oz. 30.	———
Blue vitriol,	gr. 50.	———	gr. 850.	———
Salt of hartſhorn,	gr. 50.	———	gr. 765.	———
Sugar of lead,	gr. 50.	———	gr. 595.	———
Salt of tartar,	gr. 50.	———	gr. 85.	———
Glaſs-gall,	gr. 50.	———	oz. 7½.	———
Cream of tartar,	gr. 50.	———	gr. 1000.	of boiling water.

[Fifty grains of cream of tartar may be diſſolved in 100 grains of lime-water. *Hiſt. de l'Acad. Royale.* 1732.]

Sugar of milk, dr. 7. were diſſolved in lb. 1. of water heated to the 167°.

According to Neuman's experiments, the quantity of ſalt ſoluble in an ounce of water are expreſſed in the following table. He does not mention the heat employed.

White powdered ſugar,	oz. 2.
Brown powdered ſugar,	oz. 2.
White or brown ſugar candy,	dr. 9.
Sal diureticus	oz. 1.
Epſom ſalt,	oz. 1.
Sedlitz ſalt,	dr. 6.
Pure fixed alkali,	dr. 6.
White vitriol,	oz. ½.
Martial vitriol,	oz. ½.
Sal gem,	dr. 3. ſcr. 1.
Sea-ſalt,	dr. 3.
Salt of Glauber,	dr. 2.
Sal ammoniac,	dr. 2.
Vol. ſal ammoniac,	dr. 2.
Potaſh,	dr. 2.
Blue vitriol,	dr. 2.
Pure nitre,	dr. 1. gr. 10.
Sal prunell,	dr. 1.
Soluble tartar,	dr. 1.
Alum,	ſcr. 2½.
Sal polychreſt,	ſcr. 2.
Arcanum duplicatum,	dr. ½.
Vitriolated tartar,	dr. ½.
Sugar of milk,	ſcr. 1.
Sugar of lead	ſcr. 1.
Emetic tartar,	ſcr. 1.
Borax,	gr. 15.
Salt of ſorrel	gr. 10.
White tartar,	gr. 5.
Cryſtals of tartar,	gr. 5.

Water, when ſaturated with one ſalt, is capable of diſſolving a conſiderable portion of another ſalt; and when ſaturated with this alſo, it may ſtill diſſolve a third, a fourth, or more ſalts. Thus, according to Neuman, four ounces of water that have been ſaturated with a dram and a few grains of alum, will ſtill diſſolve five drams of nitre, then half an ounce of green vitriol, ſix drams of common ſalt, three drams of ſoluble tartar, and five drams of ſugar. In the ſame manner alſo, four ounces of water ſaturated with half an ounce of nitre, will diſſolve half an ounce of white vitriol, ſix drams of common ſalt, ſix drams of ſal ammoniac, half an ounce of ſoluble tartar, and

The pureſt natural water that can be procured, as the water of rain or of ſnow, or of ſprings and rivers that flow over ſands, and are very limpid, is to be put into a well-tinned copper alembic, which muſt be very clean, or which is only employed for this purpoſe, and the diſtillation is to be promoted with a gentle fire.

The firſt portion of water that paſſes into the receiver ought to be thrown away, becauſe it waſhes the alembic and receiver, and becauſe if the water contained accidentally any volatile heterogeneous matters, theſe will riſe with the firſt portion of diſtilled water.

The diſtillation is to be diſcontinued, when two-thirds of water have nearly paſſed, becauſe what remains in the alembic, is loaded with a larger proportion of heterogeneous ſubſtances, ſome of which the water might raiſe along with it in diſtillation. *See* DISTILLATION.

Diſtilled water ought to be put into very clean bottles, and ſtopped with glaſs ſtopples.

Water is known to have been ſufficiently purified by diſtillation, when it does not change the color of the tinctures of violets, or of turnſol, and when its limpidity is not hurt by adding to it ſolutions of mercury or of ſilver in nitrous acid.

DCCXXVII. **WATERS (DISTILLED).** The *diſtilled waters of plants*, or of *other matters*, are prepared by diſtilling water from theſe ſubſtances, and are thus impregnated with ſuch principles as may be raiſed by diſtillation, with the heat of boiling water.

If the plants thus expoſed to diſtillation with water, manifeſtly contain volatile principles, as all thoſe do which have a diſtinguiſhing ſmell, we cannot doubt

and after all theſe, an entire ounce of ſugar.

Mr. Eller has publiſhed an account of the following experiments concerning the ſolution of different ſalts in the ſame water. *See Mem. of the Acad. of Berlin for the year* 1750.

In each experiment he employed *eight ounces of diſtilled water.* He found that this quantity of water, when ſaturated

With four ounces of nitre, diſſolved one ounce, five drams of fixed alkali, and half an ounce of common ſalt:

With three ounces, one dram, and one ſcruple of common ſalt, diſſolved three drams of nitre, and five drams of fixed alkali:

With three ounces and a half of foſſil ſalt, diſſolved half an ounce of nitre:

With half an ounce of cream of tartar, diſſolved half an ounce of Sedlitz ſalt, and half an ounce of fixed alkali:

With an ounce and a half of vitriolated tartar, diſſolved half an ounce of fixed alkali:

With three ounces and a half of Glauber's ſalt, diſſolved two drams of nitre, and as much ſugar.

With four ounces of ſoluble tartar, diſſolved half an ounce of pure nitre.

With four ounces of Epſom ſalt, diſſolved half an ounce of fine ſugar.

With two ounces and a half of ſal ammoniac, diſſolved five drams of foſſil ſalt.

With an ounce and a half of volatile ſalt of hartſhorn, diſſolved an ounce of nitre and half an ounce of ſugar.

With four drams and two ſcruples of borax, diſſolved half an ounce of fixed alkali.

With two ounces and a half of alum, diſſolved ſix drams of common ſalt, and one dram of Epſom ſalt:

With nine ounces and a half of green vitriol, diſſolved an ounce and a half of Sedlitz ſalt, two drams of nitre, and three ounces of refined ſugar:

With nine ounces of blue vitriol, diſſolved an ounce of nitre, three drams of common ſalt, and an ounce of ſugar:

With four ounces and a half of white vitriol, diſſolved one ounce of refined ſugar.

that their diſtilled water muſt be impregnated with their odoriferous principle, or ſpiritus rector. Theſe waters are called *aromatic waters*. *See* SPIRITUS RECTOR.

The water that is uſed in the diſtillation of all eſſential oils is found much impregnated with the odoriferous principle of the aromatic plants employed; and conſequently it is a good diſtilled water of theſe plants.

An opinion ſeems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with ſome of their principles by diſtillation; for ſuch diſtilled waters are preſcribed in many diſpenſatories. But lately, theſe diſtilled waters have been neglected, and are even conſidered only as common water. This latter kind of diſtilled waters is ſenſibly leſs impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are thoſe plants whoſe ſmell is not very perceptible, entirely deſtitute of all odoriferous principle? Could not a perſon whoſe ſenſe of ſmell was very acute and much exerciſed, diſtinguiſh plantain and other herbs commonly called inodorous from each other by ſmell, eſpecially if they were previouſly cut and bruiſed?

We may alſo obſerve, that the manner commonly employed for diſtilling ſuch waters is not well adapted to procure all the peculiar ſmell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The diſtillation is then promoted; the water is made to boil quickly; and the veſſels are ſeldom even luted. What can be expected from this bad management, but that the ſpiritus rector of theſe plants that is in very ſmall quantity, and perhaps exceedingly volatile and fugacious, ſhould be entirely diſſipated; or if any of it remains in the water, that it ſhould be diſguiſed and covered by the empyreumatic ſmell that all theſe waters have when newly diſtilled, or by the ſmell which they acquire by time, ſo that they cannot be diſtinguiſhed from each other?

But if we follow exactly the excellent method directed in the Paris Diſpenſatory; or if we improve upon this by putting the herbs recent, cut, and bruiſed, into an alembic placed in a water-bath, without adding water to them, and by diſtilling to dryneſs, with a very gentle heat and well luted veſſels; and if we then find that the ſmall quantity of water thus diſtilled from plants called inodorous has no ſmell nor taſte, and gives all the chemical proofs of pure water, we may then juſtly conſider theſe waters as deſtitute of any of the principles and virtues of the plants employed.

Waters called ſimply *diſtilled waters*, are underſtood to be thoſe that are prepared with common water. But as ſpirit of wine is alſo frequently impregnated with the odoriferous principle of plants and other ſubſtances by diſtillation, and as theſe alſo have been called *waters*, they ought to be diſtinguiſhed by the name, *aromatic ſpirituous waters*. Such are the *ſpirituous water of Lavender*, the *ſpirituous water of thyme*, &c. Theſe ſpirituous waters are alſo ſometimes called *ſpirits*, as *ſpirit of thyme*, *ſpirit of citrons*, &c.

Aromatic ſpirituous waters are impregnated with the ſmell of one ſubſtance only, or of ſeveral ſubſtances. The former are called *ſimple*, and the latter, *compound*.

Many of theſe waters are prepared for the uſes of medicine, of the toilette, and of the table. The preparation of theſe waters requires only the uſual attentions to be given to all diſtillations. Whatever relates to this ſubject may be found in *Mr. Beaumé's Elements of Pharmacy*. We ſhall there ſee that the ſtrength and agreeable flavor of theſe waters chiefly depend on the ſtrength of the ſpirit of wine employed, and eſpecially on its purity from any oil of wine, which gives the diſagreeable ſmell and taſte of common aqua vitæ. *See* SPIRIT (ARDENT).

DCCXXVIII. WATERS (HARD *or* CRUDE). Theſe names are applied to all waters that contain any ſenſible quantity of earth or ſelenites. *See* WATERS (MINERAL). (*t*)

DCCXXIX. WATER (LIME). Lime-water is ordinary water in which quicklime has been ſlaked.

Water in which quicklime has been ſlaked, or with which ſlaked quicklime is waſhed, diſſolves the part of the quicklime that is moſt attenuated, and neareſt to a ſaline ſtate: this ſubſtance, which may be conſidered as ſaline and earthy, communicates to water an alkaline, and ſomewhat acrid taſte. The effects of lime-water in chemical mixtures are ſimilar to thoſe produced by quicklime. *See* QUICK-LIME.

Although lime-water contains no volatile principle, it ought nevertheleſs to be preſerved in full and well cloſed bottles: otherwiſe the ſaline earthy matter diſſolved in it, to which it owes all its peculiar properties, would be ſeparated from it, in proportion as the water ſhould be evaporated, and would appear on the ſurface in form of a cruſt, called *cream of lime*. The quantity of calcareous matter that is thus ſeparated from lime-water, is even greater than it ought to be, if it was exactly proportionate to the evaporation of the water. The cauſe of which probably is, that the firſt portions of this matter which cryſtallize, draw along with them another part that would otherwiſe have remained diſſolved in the water. Hence lime-water, by long expoſure to air, loſes much of its ſtrength, and at laſt becomes almoſt inſipid. *See a note ſubjoined to the article* QUICK-LIME.

(*t*) *Hard waters* are thoſe in which ſoap does not diſſolve uniformly, but is curdled. The diſſolving power of hard water is leſs than that of *ſoft*; and hence its unfitneſs for bleaching, dyeing, boiling leguminous vegetables, and for many other purpoſes of economy and arts. One cauſe of the hardneſs of water is, that it contains ſome ſalt that may be decompoſed by ſoap, the alkali of which uniting with the acid of the ſalt, the oil of the ſoap ſeparates, and the ſoap is ſaid to be curdled. Hardneſs of water proceeding from this cauſe may be diſcovered and cured by adding ſome drops of a ſolution of fixed alkali. The ſalts capable of rendering water hard, are not only ſelenites, which is a very frequent cauſe of the hardneſs of water, but any other earthy or metallic ſalt that may be contained in the water, as all theſe are capable of being decompoſed by fixed alkali. Such are the marine ſalt with baſis of magneſia, or of calcareous earth, vitriolic ſalt with baſis of magneſia called Epſom ſalt, green vitriol, and a nitrous ſalt with earthy baſis, to which Dr. Home attributes the hardneſs of ſeveral waters examined by him. The hardneſs of water has been by ſome perſons attributed to common ſalt. But Dr. Home in his *Eſſay on Bleaching* has ſhewn, that neither pure common ſalt, nor any other ſalt with baſis of fixed alkali, give any hardneſs to water, but that this quality may be given to water by the common ſalt which is generally ſold, becauſe this contains ſome part of the earthy ſalts of ſea-water, or of the water of ſalt-ſprings.

Fixable air which waters frequently contain, is another cauſe of the hardneſs of water. This air unites with the alkali of ſoap, renders it mild, and thus weakens its union with the oil. *See* AIR FIXABLE, *and* ALKALI (FIXED). This fixable air, by expoſure of the water during ſome time in open veſſels, exhales; by which means, water is rendered ſoft, and any calcareous earth

DCCXXX. WATER (MERCURIAL). This name is given to a ſolution of mercury in nitrous acid, diluted with a greater or leſs quantity of common water.

This liquor produces very good effects, as an eſcharotic, and even as a cauſtic in ſome diſeaſes of the ſkin that are external, local, and eſpecially venereal. Some perſons uſe this mercurial water internally; but as it muſt be a dangerous remedy, it ought not to be employed.

DCCXXXI. WATERS (MINERAL). All waters naturally impregnated with any heterogeneous matter which they have diſſolved within the earth may be called *mineral waters*, in the moſt general and extenſive meaning of that name; in which are therefore comprehended almoſt all thoſe that flow within, or upon the ſurface of the earth: for almoſt all theſe contain ſome earth or ſelenites. But waters containing only earth or ſelenites are not generally called *mineral*, but *hard* or *crude waters*.

Hard waters, when tried by the chemical proofs hereafter to be mentioned for diſcovering the nature of mineral waters, ſhew no marks of an acid or of an alkali, nor of any volatile, ſulphureous, or metallic matters. Waters which contain a diſengaged calcareous earth, change the color of ſyrup of violets to a green; and thoſe that contain ſelenites, being mixed with a ſolution of mercury in nitrous acid, form a turbith mineral; and when a fixed alkali is added, they are rendered turbid, and a white ſediment is precipitated. Theſe waters alſo do not diſſolve ſoap well. From theſe we may know, that any water which produces theſe effects is a hard, earthy, or ſelenitic water.

Although the waters of the ſea, and ſaline ſprings, be not generally enumerated amongſt mineral waters, they might nevertheleſs be juſtly conſidered as ſuch. For beſides earthy and ſelenitic matters, they alſo contain a large quantity of mineral ſalts. We ſhall therefore conſider them as ſuch in this article.

Mineral waters, properly ſo called, are thoſe in which ſpirituous, ſulphureous, ſaline or metallic ſubſtances are diſcovered by chemical trials. As many of theſe waters are employed ſucceſsfully in Medicine, they are alſo called *medicinal waters*.

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or iron which may be diſſolved in the water merely by means of this air, as Mr. Cavendiſh and Mr. Lane have ſhewn [*Philoſ. Tranſ.* 1767 *and* 1769.] are precipitated.

By boiling, the hardneſs of water proceeding from fixable air may be cured, but that from earthy or metallic ſalts cannot.

Spring-waters are frequently hard. River water is generally ſoft. The ſmall quantity of earthy ſalts contained in rain and ſnow waters, according to Mr. Margraaf's analyſis, does not ſenſibly render them hard.

As rivers are formed by the junction of many ſprings, the greater hardneſs of the water of the latter ſeems to be not eaſily explicable. Does this difference betwixt theſe two waters proceed from fixable air being contained more copiouſly in ſprings, than in rivers, by the motion and free expoſure of which it is moſtly exhaled? or from a larger quantity of atmoſpherical air being contained in the water of rivers by means of their motion and free expoſure, than in the water of ſprings; as a mixture of atmoſpherical air with water is known to encreaſe the diſſolving power of this liquid? or from both theſe cauſes united?

Mineral waters receive their peculiar principles by paſſing through earths containing ſalts, or pyritous ſubſtances that are in a ſtate of decompoſition. *See* PYRITES.

Some of theſe waters are valuable from the quantity of uſeful ſalts which they contain, particularly of common ſalt, great quantities of which are obtained from theſe waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that ſalt only which is moſt valuable in commerce. *See* WATER *of the* SEA; and WATER *of* SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters conſiſt, ought to be carefully examined. Many of theſe waters have been accurately analyſed by able chemiſts and phyſicians.

But notwithſtanding theſe attempts, we are far from having all the certainty and knowledge that might be deſired on this important ſubject; for this kind of analyſis is perhaps the moſt difficult of any in chemiſtry.

Almoſt all mineral waters contain ſeveral different ſubſtances, which being united with water may form with each other numberleſs compounds. Frequently ſome of the principles of mineral waters are in ſo ſmall quantity, that they can ſcarcely be perceived; although they may have ſome influence on the virtues of the water, and alſo on the other principles contained in the water.

The chemical operations uſed in the analyſis of mineral waters, may ſometimes occaſion eſſential changes in the ſubſtances that are to be diſcovered. And alſo, theſe waters are capable of ſuffering very conſiderable changes by motion, by reſt, and by expoſure to air.

Probably alſo the variations of the atmoſphere, ſubterranean changes, ſome ſecret junction of a new ſpring of mineral or of pure water; laſtly, the exhauſtion of the minerals whence waters receive their peculiar principles, are cauſes which may occaſionally change the quality of mineral waters.

We need not therefore wonder that the reſults of analyſes of the ſame mineral waters made by different chemiſts, whoſe ſkill and accuracy are not queſtioned, ſhould be very different.

The conſequences of what we have ſaid on this ſubject are, that the examination of mineral waters is a very difficult taſk; that it ought not to be attempted but by profound and experienced chemiſts; that it requires frequent repetitions, and at different times; and laſtly, that no fixed general rules can be given concerning theſe analyſes.

As this matter cannot be thoroughly explained without entering into details connected with all the parts of chemiſtry, we ſhall here mention only the principal reſults, and the moſt eſſential rules, that have been indicated by the attempts hitherto made on this ſubject.

We may admit the diviſion or arrangement of mineral waters into certain claſſes, propoſed by ſome of the beſt chemiſts and naturaliſts.

Some of theſe waters are called *cold*, becauſe they are not naturally hotter than the atmoſphere. Some of them are even colder, eſpecially in ſummer.

Thoſe are called *hot mineral waters*, which in all ſeaſons are hotter than the air. Theſe are of various degrees of heat, and ſome of them are almoſt as hot as boiling water. In ſome mineral waters certain volatile, ſpirituous and elaſtic principles may be perceived, by a very ſenſible piquant taſte; this principle is called the *gas* or the *ſpirit of waters*.

The waters which contain this principle are generally lighter than pure water. They ſparkle and emit bubbles, at their ſpring, but eſpecially when they are ſhook, and poured from one veſſel into another. They ſometimes break the bottles containing them, when theſe are well corked, as fermenting wines ſometimes do. When mixed with ordinary wine, they give to it the piquancy and ſparkling quality of Champaigne wine.

This volatile principle and all the properties of the water dependant upon it are loſt merely by expoſure to air. The waters containing this principle are diſtinguiſhed by the name of *ſpirituous mineral waters*.

Other diviſions of mineral waters may be made, relatively to ſome of their predominant principles. Hence ſome waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may obſerve the following rules:

Experiments ought to be made near the ſpring, if poſſible.

The ſituation of the ſpring, the nature of the ſoil, and the neighbouring riſing grounds ought to be examined.

Its ſenſible qualities, as its ſmell, taſte, color, are to be obſerved.

Its ſpecific gravity and heat are to be aſcertained by the hydroſtatical balance and the thermometer.

From the properties above-mentioned of ſpirituous mineral waters, we may diſcover whether it be one of this claſs. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing ſome of this water. By ſhaking the water, any *gas* that it may contain will be diſengaged, and will ſwell the bladder. If the neck of the bladder be then tyed with a ſtring above the bottle, and be cut below this ſtring, ſo as to ſeparate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Laſtly, we muſt obſerve the changes that are ſpontaneouſly produced upon the water in cloſe and in open veſſels, and with different degrees of heat. If by theſe means any matter be cryſtallized or depoſited, it muſt be ſet apart for further examination.

Theſe preliminary experiments and obſervations will almoſt certainly indicate, more or leſs ſenſibly, ſomething concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We muſt then proceed to the decompoſition of the water either without addition and merely by evaporation and diſtillation, or with the addition of other ſubſtances, by means of which the matters contained in the water may be precipitated, and diſcovered. It is not material which of theſe two methods be firſt practiſed, but it is quite neceſſary that the one ſhould ſucceed the other. If we begin by evaporating and diſtilling, theſe operations muſt be ſometimes interrupted, that the ſeveral principles which riſe at different times of the diſtillation may be obtained and examined ſeparately, and alſo to allow the ſeveral ſalts that may be contained, to cryſtallize by the evaporation and by cold. *See* EVAPORATION, DISTILLATION, *and* CRYSTALLIZATION.

The ſubſtances generally found in mineral waters, are almoſt always combinations of vitriolic acid, and thoſe of marine acid, together with the ſeveral matters that theſe acids are capable of diſſolving.

The following combinations of vitriolic acid are found in mineral waters.

1. *Volatile ſulphureous acid.* This is ſeldom found, both becauſe it eaſily loſes its phlogiſton, and becauſe it muſt almoſt always meet with ſome ſubſtance that it is capable of diſſolving.

2. *Sulphur.* This is found ſometimes ſingly, but generally in form of a liver of ſulphur. In theſe waters, ſulphur is formed into a hepar by means of calcareous earth, or of mineral alkali.

3. *Vitriolic ſalts with earthy baſes.* Theſe ſalts are almoſt always *ſelenitic*, that is, their acid is combined with a calcareous earth. Sometimes, but not ſo frequently, they are *aluminous*, when their acid happens to be united with an argillaceous earth.

4. *Vitriols. Martial vitriol* is frequently contained in mineral waters; *vitriol of copper* is ſometimes but ſeldom, and *vitriol of zinc* is ſtill more rarely found in theſe waters. The vitriols of other metallic ſubſtances are ſcarcely ever, but in very ſingular caſes, found in water.

5. Laſtly, *vitriolic ſalts with baſis of fixed alkali.* This is always *Glauber's ſalt.* Neither *vitriolated tartar* nor *vitriolic ammoniacal ſalt* are ever found, unleſs by ſome ſingular accident, in mineral waters.

The combinations of marine acid that are contained in mineral waters are *common ſalt*, and *marine ſalt with earthy baſis.* For no combinations of this acid with phlogiſton are known, and it is very ſeldom found united with any metallic ſubſtance.

Compounds formed of the nitrous acid are, in a manner, ſubſtances extraneous to the mineral kingdom, ſince this acid is never produced but upon the ſurface of the earth, and from vegetable and animal matters. *See* ACID (NITROUS) *and* NITRE. This acid cannot therefore be found in waters but very accidentally.

Theſe are the principal ſubſtances that form almoſt all theſe waters. We ſhall now ſhew the proofs by means of which they may be diſcovered in water, without decompoſing the water by evaporation or by diſtillation.

If any portion of diſengaged acid or alkali be contained in water, it may be known by the taſte, by changing the color of violets or of turnſol, and by adding the preciſe quantity of acid or of alkali that is neceſſary for the ſaturation of the contained diſengaged ſaline matter.

Volatile ſulphureous acid, ſulphur, and liver of ſulphur, may be diſcovered in waters by their ſingular ſmell, by the black color which theſe ſubſtances give to white metals or to their precipitates, but eſpecially to ſilver.

Vitriolic ſalts with earthy baſis may be diſcovered in water by two proofs: 1. By adding ſome fixed alkali, which decompoſes all theſe ſalts, and precipitates their earthy baſis; and, 2. By adding a ſolution of mercury in nitrous acid, which alſo decompoſes theſe ſalts, and forms a *turbith mineral* with their acid.

Martial vitriol or iron combined with any acid, ſhews itſelf in waters by blackening an infuſion of galls, or by forming a Pruſſian blue with the phlogiſticated alkaline lixivium.

The vitriol of copper, or copper diſſolved by any acid, may be diſcovered by adding ſome of the volatile ſpirit of ſal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the ſurface of which the copper is precipitated in its natural or metallic ſtate.

Glauber's ſalt is diſcovered by adding a ſolution of mercury in nitrous acid, and forming with it a turbith mineral; or by cryſtallization.

Common ſalt contained in waters forms with a ſolution of ſilver in nitrous acid a white precipitate, or luna cornea. It may alſo be known by its cryſtallization. Marine ſalt with earthy baſis produces the ſame effect upon ſolution of ſilver. It alſo forms a precipitate when fixed alkali is added. The acrimony, bitterneſs, and deliqueſcency of this ſalt ſerve to diſtinguiſh it.

The proofs related for the examination of mineral waters are only thoſe which are moſt eſſential. Many others may be made to confirm the former proofs: but the details of theſe are too extenſive to be inſerted here. We ſhall add only two of theſe, becauſe they are very general, and may be very uſeful.

The firſt is the production of artificial ſulphur, or of the volatile ſulphureous acid; by which means the vitriolic acid may be diſcovered in any combination whatever. For this purpoſe the matter to be examined muſt be mixed with any inflammable ſubſtance, and expoſed to a red heat. If this matter contained but a particle of vitriolic acid, it would be rendered ſenſible by the ſulphur, or by the volatile ſulphureous acid thence produced. *See* SULPHUR.

The ſecond general proof for mineral waters which we ſhall mention here ſerves to diſcover any metallic ſubſtance whatever, diſſolved in water by any acid. This proof conſiſts in adding ſome of the liquor ſaturated by the coloring matter of Pruſſian blue, diſcovered and deſcribed by Mr. Macquer in his Memoir upon Pruſſian Blue. This liquor produces no effects upon any neutral ſalts with earthy or alkaline baſes, but decompoſes all metallic ſalts: ſo that if no precipitate be formed upon adding ſome of this liquor, we may be certain that the water does not contain any metallic ſalt; and on the contrary, if a precipitate is formed, we may certainly infer that the water does contain ſome metallic ſalt.

Two kinds only of *gas*, or the ſpirituous volatile part of ſome waters, are hitherto known; of which one is the volatile ſulphureous acid, and the other is pure air, as Mr. Venel has ſhewn in the waters of Sel or Selters. Air united ſuperabundantly with ſpirituous waters is the chief cauſe of their lightneſs, piquancy, and ſparkling.

When the nature and quantities of the principles contained in a mineral water are aſcertained by ſuitable experiments, it is very proper to attempt to imitate artificially this water, by adding to pure water the ſame proportions of the ſame ſubſtances, as Mr. Venel has done in examining ſeveral waters, eſpecially that of Selters.

We may eaſily perceive the neceſſity of uſing no veſſels in theſe experiments, but ſuch as are perfectly clean and rinſed with diſtilled water; of weighing the products of the experiments very exactly; of making the experiments upon as large quantities of water as is poſſible, eſpecially the evaporations, cryſtallizations, and diſtillations; and of repeating all experiments ſeveral times. We may further obſerve, that the mixtures from which any precipitates might be expected, ought to be kept two or three days, becauſe many of theſe precipitates require that time or more to appear, or to be entirely depoſited.

We ſhall now endeavor to explain how mineral waters become impregnated with their principles.

The *ſelenitic* parts of water are received by this fluid while it flows through gypſeous earths and ſtones, theſe being compoſed of ſelenites, which is ſoluble in water.

The mines of ſal gem which are in many places, and particularly where ſalt-ſprings are, furniſh the waters which flow through them, and perhaps the ſea itſelf, with the *common ſalt* that they contain.

When a water once contains common ſalt, it may become impregnated with *Glauber's ſalt* by paſſing through clay; the vitriolic acid that is always contained in argillaceous earths, decompoſing a part of the common ſalt of the water, with the baſis of which it forms the Glauber's ſalt; while the marine acid now diſengaged will unite with the firſt calcareous particles that it meets, and form a *marine ſalt with earthy baſis*, which is accordingly always found in ſea-water, and in ſalt-ſprings.

When water impregnated, or not, with ſaline principles flows through parts of the earth containing pyrites in a ſtate of decompoſition, it becomes impregnated with *ſulphur*, with *martial vitriol*, with *vitriol of copper*, with *alum*, and with *other ſalts*; and frequently with ſeveral of theſe ſubſtances at the ſame time, according to the nature of the pyrites. *See* PYRITES.

The *heat of hot mineral waters* can be only acquired by waſhing large maſſes of pyrites and other ſimilar minerals in a ſtate of ſpontaneous decompoſition, during which they always acquire conſiderable heat.

Laſtly, the aerial *gas* of ſome mineral waters may have been diſcharged from ſome of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were diſſolved by the water, or which were combined after this ſolution. For we know that in almoſt all ſolutions much air is extricated; and this air being well divided and diffuſed among the particles of water, adheres to them, and in ſome meaſure combines with them ſuperabundantly. Mr. Venel has made upon this ſubject a fine experiment, that proves the truth of the above-mentioned theory, which was firſt given by him. He added to common water as much marine acid and mineral alkali as were ſufficient to form as much common ſalt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded ſlowly and without efferveſcence, becauſe the ſaline matters were much diluted; and when the combination was completed, the artificial water was become ſpirituous and aerial, like the natural water that he imitated. *See the particular articles of all the ſubſtances mentioned that relate to mineral waters; from a knowledge of the properties of which ſubſtances many explanations on this ſubject may be deduced, too long to be here inſerted.* (u)

(u) The *gas* which gives the ſparkling and inebriating qualities to many mineral waters, ſeems not to differ from the vapor extricated from efferveſcing and fermenting ſubſtances, called *fixable air*. *See* AIR (FIXABLE). The Honourable Mr. Cavendiſh has added to his former important diſcoveries concerning fixable air, one that throws much light on the nature

DCCXXXII. WATERS (MOTHER). This name is given to the liquor that remains after as much of the ſaline ſubſtances contained in a water has been ſeparated as can be by the uſual methods, evaporation and cooling, and from which therefore no more cryſtals can be obtained, without much difficulty, though it ſtill remains impregnated with ſalts. Theſe mother-waters are very different, according to the kinds of ſalts with which the waters were originally impregnated. They are generally very heavy, acrid, and red.

The nature of mother-waters was a long time very imperfectly underſtood. They were conſidered as liquors loaded with greaſy and viſcid matters, by means of which the ſalts contained were prevented from cryſtallizing.

A portion of cryſtallizable ſalt, ſimilar to thoſe already extracted, does indeed remain in the mother-waters; and perhaps alſo the cryſtallization of theſe may be impeded by the viſcid matters that are ſometimes contained in theſe waters: but generally the greateſt part of the matter contained in mother-waters is

nature of many mineral waters. This diſcovery is, that by means of fixable air, and without the intervention of any acid, calcareous earth is diſſolved in ſome mineral waters. He found that the quantity of this air that was contained in Rathbone-place-water, relatively to the quantity of calcareous earth contained in that water, was about twice as much as is uſually combined with an equal quantity of calcareous earth; and that the earth might be precipitated from this water by driving off the fixable air by heat, or by abſorbing it by the addition of lime-water. Does not this ſolution of calcareous earth by fixable air confirm a conjecture concerning the analogy of this vapor with acids? It ſeems very extraordinary that calcareous earth ſaturated with its uſual quantity of air ſhould be unſoluble in water, but that it may be rendered ſoluble, either by depriving it entirely of this air, as it is in lime-water, or by uniting it with a ſuperabundant quantity of air, as it is in the water of Rathbone-place. *See Phil. Tranſ. for the Year* 1767.

Mr. Lane has diſcovered another inſtance of the diſſolving power of fixable air upon iron, and has, by ſome ingenious experiments, ſhewn the probability that this metal is diſſolved in many mineral waters by means only of that air. He found that pure diſtilled water, having been impregnated with the fixable air ariſing from efferveſcing or fermenting ſubſtances, was rendered capable of diſſolving a ſenſible portion of iron; and that this artificial chalybeate water, by expoſure to air, loſt entirely its property of tinging an infuſion of galls. As ſeveral chalybeate mineral waters do alſo, by expoſure to air, entirely loſe their property of tinging an infuſion of galls; and as waters containing iron diſſolved by means of vitriolic acid, though a conſiderable ſediment is alſo depoſited from them, do never entirely loſe this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this air. He further ſhews, from experiments, that iron cannot be ſo entirely precipitated from its ſolution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this ſolution ſhall loſe its power of tinging an infuſion of galls; but that the iron may be ſo perfectly precipitated from the above-mentioned ſolutions by means of cauſtic alkali, or of lime-water; and hence he infers, that in the former caſe the portion of iron that is not precipitated is kept ſuſpended or diſſolved by means of the fixable air extricated by the acid of the ſolution from the mild alkali or earth. *See Phil. Tranſ. for the Year* 1769.

In the above article concerning mineral waters, the Author of the Dictionary conſiders nitre or nitrous acid as ſubſtances not to be found in native waters, but by ſome accidental occurrence. Nevertheleſs, from the experiments of Mr. Margraaf on the waters of the wells at Berlin, of Dr. Heberden on thoſe of London, and of Dr. Home on thoſe of ſome wells in Scotland, we have reaſon to believe, that true nitre and a nitrous ſalt with earthy baſis are frequently contained in waters of ſprings, eſpecially in towns.

compoſed of ſalts that are deliqueſcent and different from thoſe already obtained by cryſtallization. We are certain, at leaſt, that the mother-waters of ſea-ſalt and of nitre are formed almoſt entirely of theſe ſalts, which have a certain kind of adheſion to the cryſtallizable ſalts, and which therefore prevent the cryſtallization of the laſt portions of theſe. The mother-water of common ſalt contains a conſiderable quantity of marine ſalt with earthy baſis, and the mother-water of nitre contains not only marine ſalt with earthy baſis, but alſo a conſiderable quantity of nitre with earthy baſis: hence, if a fixed alkali be added to theſe waters, a white earthy precipitate is formed ſo copiouſly, that the whole becomes a kind of paſte. By diluting this paſte with much water, the earth may be obtained by filtration. The earth when edulcorated is very white, and of a calcareous nature. It is called *magneſia*. (*x*)

If vitriolic acid be added to theſe mother-waters, a very copious white precipitate is likewiſe formed. This precipitate alſo proceeds from the union of this acid with the calcareous earth of the earthy ſalts, by which a ſelenites is formed. This ſelenites, not being ſoluble in ſo ſmall a quantity of water as that of the mother-water employed, is moſtly precipitated in form of an earthy ſediment conſiſting of very minute cryſtals. *See* SALTS *with* EARTHY BASIS, *and* MAGNESIA.

DCCXXXIII. WATER *of* RABEL. The water of Rabel is vitriolic acid dulcified by mixture with rectified ſpirit of wine. Rabel, the inventor of this liquor, which is uſed in medicine, employed an expenſive apparatus in the preparation of it. He obtained the vitriolic acid from pyrites: but ſince his time, the proceſs has been much ſimplified, as it ought to be. One part of oil of vitriol is mixed with three parts of rectified ſpirit of wine, and the mixture is digeſted in a well-cloſed veſſel. The vitriolic acid acts upon all the principles of the ſpirit of wine, and combines with them in a certain degree during this digeſtion: hence the acidity of the liquor is conſiderably diminiſhed, but not perfectly deſtroyed. This water of Rabel may be conſidered as a dulcified vitriolic acid. *See* ETHER.

Water of Rabel is employed in medicine as an aſtringent, from the property which the vitriolic acid has of conſtringing the fibres and veſſels. It requires to be diluted in ſome proper vehicle, as in potions or juleps.

DCCXXXIV. WATER (SEA). Sea-water, and the waters of many ſalt-lakes, wells, and ſprings, containing various kinds of ſalts, is in much greater quantity than freſh-water.

We may ſay in general, that all natural ſalt-waters contain four kinds of ſalts, namely, common ſalt, Glauber's ſalt, ſelenites, and marine ſalt with earthy baſis. Theſe ſalts are in different quantities and proportions, according to the nature of the waters; but the quantity of the common ſalt is always greater than that of any other.

(*x*) Magneſia is an earth not convertible into quicklime, therefore different from calcareous earth, with which the Author of the Dictionary confounds it, and is poſſeſſed of peculiar properties. *See the article* MAGNESIA, *and the* NOTE *ſubjoined*. The mother-waters of common ſalt and of nitre do alſo contain ſome marine and nitrous ſalts with baſis of calcareous earth, as appears from the formation of ſelenites upon adding vitriolic acid, as is mentioned in the following paragraph of the text.

All theſe waters have a ſaline, and more or leſs of an acrid, bitter taſte. The acrimony and bitterneſs of theſe waters are generally attributed to bituminous matters ſuppoſed to be contained in them: but I can affirm, that I have made many experiments on large quantities of theſe ſeveral waters, and that I could never find any ſenſible quantity of bitumen. The bitterneſs, therefore, of theſe waters ought to be attributed to the Glauber's ſalt, which is bitter, and eſpecially to the marine ſalt with earthy baſis, which is very bitter and acrid.

Sea-water is not every-where impregnated with an equal quantity of ſalt. Generally, it has been obſerved to contain more ſalt in hot than in cold climates. The quantity of common ſalt contained in ſea-water is to the quantity of that water as three or four to a hundred. The water is conſequently far from being ſaturated with that ſalt; for water is capable of diſſolving nearly a fourth part of its weight of common ſalt.

Common ſalt is obtained from ſea-water by evaporation alone, and not by alternate evaporation and cooling; becauſe this ſalt is equally ſoluble in cold as in hot water. *See* CRYSTALLIZATION, *and* SALT (COMMON).

In the ſouthern provinces of France, and in all equally hot or hotter climates, ſea-water is evaporated in open air, and merely by the heat of the ſun in ſummer, by which means the common ſalt is obtained. For this purpoſe, large baſons are made in the ground near the ſea, called ſalt-marſhes. They are ſo diſpoſed that the ſea-water may flow into them at certain tides, and be retained there. Theſe marſhes are divided into many compartments, communicating with each other, into which any required quantity of water may be admitted. The water in theſe is of a ſmall depth, that the evaporation may advance more quickly. When the water is ſufficiently evaporated, and the ſalt is cryſtallized, more water is admitted, till a ſufficient quantity of ſalt is obtained, which is then gathered in heaps and drained.

In the northern provinces of France common ſalt is obtained from ſea-water in the following manner:

A quantity of ſand moiſtened with ſea-water is expoſed to the ſun and dried, which is quickly done, becauſe the ſea-water is almoſt entirely near the ſurface of the ſand. The ſand, which then becomes covered with a conſiderable quantity of ſalt, is to be waſhed with as much water as is neceſſary for the ſolution of the ſalt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the ſalt is cryſtallized.

Wallerius ſays, that in northern countries the ſalt in ſea-water is concentrated by expoſure to intenſe cold, by which great part of the water is frozen, and the unfrozen part, which contains almoſt all the ſalt, is afterwards evaporated by fire, till the ſalt is cryſtallized.

After the common ſalt has been thus obtained by theſe operations from ſea-water, a liquor, called *mother-water*, remains that contains much ſalt, which cannot be cryſtallized. If this water be further evaporated, and then expoſed to cold, a certain quantity of Glauber's ſalt will be formed, which is very impure and badly cryſtallized, and is generally called *Epſom ſalt*. *See* SALT (EPSOM). (y)

(y) The ſalt called *Epſom ſalt*, or ſal catharticus amarus, large quantities of which are obtained from the mother-water remaining after the evaporation of ſea-water, and which

Laſtly, the remaining part of the mother-water contains ſcarcely any thing but marine ſalt with earthy baſis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magneſia of common ſalt*. *See* WATER (MOTHER), *and* MAGNESIA.

DCCXXXV. WATER *of* SALT-SPRINGS. The water of almoſt all ſalt ſprings, at leaſt of thoſe from which common ſalt is obtained, contains exactly the ſame principles as ſea-water, but generally in a larger quantity. Some of theſe ſprings contain ſixteen pounds of ſalt in a hundred pounds of water. Such, for inſtance, is that of Dieuſe in Lorraine, one of the beſt ſalt-works known. Other ſprings contain a much ſmaller proportion of ſalt; ſuch is that of Montmorot in Franche-compté.

Salt is obtained from theſe ſalt-ſprings generally by evaporation over the fire; at leaſt, it is ſo in Lorraine, and in Franche-compté: but that the expence of fuel may be leſſened, the water, when weakly impregnated, is previouſly concentrated by frequently pouring it upon bundles of twigs or faggots under buildings that are covered, but open at all the ſides, called *graduating houſes*. The water raiſed by pumps to the top of theſe buildings falls upon the faggots, by which it is divided into a ſhower, its ſurface is thereby encreaſed, and the evaporation is promoted by the free current of air that paſſes through the open ſides of the building. When, by this means, the water is ſo concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of ſalt, it is then evaporated over the fire in the uſual manner.

As theſe waters are much more impregnated with ſaline principles than ſea-water, and as their evaporation is more quickly finiſhed, we ſhall confirm what we have ſaid concerning the evaporation and formation of the ſeveral ſalts in ſea-water, by deſcribing the method employed in the evaporation of the water of the ſalt-ſprings of Lorraine and Franche-compté.

This water is evaporated in very large veſſels made of plates of iron, capable of containing from eight to nine or ten thouſand gallons of water, called *ſalt-pans*, the depth of which is about fifteen or ſixteen inches.

In theſe the water is boiled ſome time, during which a ſaline earthy matter, called *ſchlot or ſcratch*, is depoſited, and is carefully to be ſeparated. This ſcratch is a ſelenites, which of all the ſaline matters contained in the water is the leaſt ſoluble, and conſequently cryſtallizes firſt. This ſelenites draws along with it ſome of the other ſalts, and principally Glauber's ſalt, which ſeems to have ſome degree of adheſion to it.

When the ſelenites is ſeparated, the common ſalt, being in greater quantity than the other ſalts, begins to cryſtallize and form cubes. That larger cryſtals of this ſalt may be formed, the water is made to boil very ſlowly, till the common ſalt ceaſes to cryſtallize. The water that remains is very heavy, much impregnated with ſalt, of an acrid and bitter taſte. This is the *mother-water*.

This mother-water contains ſtill ſome common ſalt, ſome Glauber's ſalt, and eſpecially a large quantity of marine ſalt with earthy baſis. The Glauber's

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which is ſimilar to the ſalt obtained by evaporation of the mineral water at Epſom, is compoſed of vitriolic acid and magneſia; it is therefore improperly ſaid to be Glauber's ſalt, which conſiſts of vitriolic acid united with mineral alkali, although ſome of this latter ſalt alſo is ſaid to be contained in ſea-water.

ſalt remains chiefly in the mother-waters, becauſe it is much more ſoluble in hot than in cold water, and cryſtallizes more readily by cold than by evaporation. The marine ſalt with earthy baſis remains almoſt entirely in the mother-water, becauſe it is deliqueſcent, and not ſuſceptible of a true cryſtallization. *See* WATER (MOTHER).

The ſeveral ſalts contained in waters of ſalt-ſprings are thus ſeparated from each other: but this ſeparation is not very accurate. To render it more compleat, other means muſt be employed. The fundamental principles of the perfect purification of the ſeveral ſalts confounded together in the ſame water are explained at the article CRYSTALLIZATION. To avoid repetitions, we refer to that article. *See alſo the articles* SELENITES, SALT (COMMON), SALT *of* EPSOM, SALT *of* GLAUBER, SALT (MARINE) *with* EARTHY BASIS, WATER (MOTHER), *and* WATERS (MINERAL).

DCCXXXVI. WAX. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long conſidered as a reſin, from ſome properties common to it with reſins. It has the ſame conſiſtence as reſins have, and, like them, it furniſhes an oil and an acid by diſtillation, and is ſoluble in all oils: but in ſeveral reſpects it differs ſenſibly from reſins. Like theſe, wax has not a ſtrong aromatic taſte and ſmell, but a very weak ſmell, and, when pure, no taſte. With the heat of boiling water no principles are diſtilled from it; whereas, with that heat, ſome eſſential oil, or, at leaſt, a ſpiritus rector is obtained from every reſin. Further, wax is unſoluble in ſpirit of wine. If wax be diſtilled with a heat greater than that of boiling water, it may be decompoſed, but not ſo eaſily as reſins can. By this diſtillation a ſmall quantity of water is firſt ſeparated from the wax, and then ſome very volatile and very penetrating acid, accompanied with a ſmall quantity of a very fluid and very odoriferous oil. As the diſtillation advances, the acid becomes more and more ſtrong, and the oil more and more thick, till its conſiſtence be ſuch that it becomes ſolid in the receiver, and is then called *butter of wax*. When the diſtillation is finiſhed, nothing remains but a ſmall quantity of coal, which is almoſt incombuſtible from the want of ſome ſaline matter. *See* COAL.

Wax cannot be kindled, unleſs it be previouſly heated and reduced into vapors; in which reſpect it reſembles fat oils. The oil and butter of wax may, by repeated diſtillations, be attenuated and rendered more and more fluid, becauſe ſome portion of acid is thereby ſeparated from theſe ſubſtances; which effect is ſimilar to what happens in the diſtillation of other oils and oily concretes: but this remarkable effect attends the repeated diſtillation of oil and butter of wax, that they become more and more ſoluble in ſpirit of wine; and that they never acquire greater conſiſtence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glaſs veſſel open, or careleſsly cloſed, during twenty years, without acquiring a more ſolid conſiſtence.[*] We may remark, that wax, its butter, and its oil, differ entirely from eſſential oils and reſins in all the above-mentioned properties, and that in all theſe they perfectly reſemble ſweet oils. *See* OILS (ESSENTIAL), RESINS, *and* OILS (SWEET EXPRESSED).

We may therefore conclude from what has been ſaid, as Mr. Macquer has done in his Elements of Chemiſtry, and in his Memoir upon Oils, that wax only reſembles reſins in being an oil rendered concrete by an acid; but that it differs eſſentially from theſe in the kind of the oil, which in reſins is of the nature of eſſential oils, while in wax and in other analogous oily concretions, (as butter of milk, butter of cocoa, fat of animals, ſperma-ceti, and a wax obtained from a tree in Louiſiana) it is of the nature of ſweet, unctuous oils that are not aromatic and not volatile, and are obtained from vegetables by expreſſion.

Wax is very uſeful, eſpecially as a better material than any other for candles.

Wax may be deprived of its natural yellow diſagreeable color, and be perfectly whitened, by expoſure to the united action of air and of water, by which method the color of many ſubſtances may be deſtroyed.

The art of bleaching wax conſiſts in encreaſing its ſurface. For which purpoſe, it muſt be melted with a degree of heat not ſufficient to alter its quality, in a cauldron ſo diſpoſed that the melted wax may flow gradually through a pipe at the bottom of the cauldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the ſurface of this cylinder is always moiſtened with cold water, the wax falling upon it does not adhere to it, but quickly becomes ſolid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off theſe ribbands as faſt as they are formed, and diſtributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are ſupported about a foot and a half above the ground, in a ſituation expoſed to the air, the dew, and the ſun. The thickneſs of the ſeveral ribbands, thus placed upon the frames, ought not to exceed an inch and a half; and they ought to be moved from time to time, that they may all be equally expoſed to the action of the air. If the weather be favorable, the color will be changed in the ſpace of ſome days. It is then to be re-melted and formed into ribbands, and expoſed to the action of the air as before. Theſe operations are to be repeated till the wax be rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow color of the wax is evidently deſtroyed by the combined action of the air, of the water, and of the ſun. As the volatile, ſulphureous acid has the property of deſtroying ſtill more quickly almoſt all the colors of vegetables, perhaps this bleaching might be ſhortened by expoſing ribbands of yellow wax to the vapor of ſulphur, as is practiſed for wool and ſilk.

Every kind of wax is not equally capable of being whitened, the color of ſome adhering ſo ſtrongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This obſervation I have received from Mr. Trudon, proprietor of the manufactory of wax, at Antoni, near Paris.

Wax is employed for many purpoſes in ſeveral arts. It is alſo uſed in medicine as a ſoftening, emollient, and relaxing remedy; but it is only uſed externally, mixed with other ſubſtances. It is an ingredient in many pomatums, cerates, ointments, and plaſters, to moſt of which it gives the due conſiſtence. Upon this ſubject may be conſulted Mr. Beaumé's Elements of Pharmacy, a work containing many excellent obſervations.

DCCXXXVII. WHEY. *See* Milk.

DCCXXXVIII. WHITE (SPANISH). This name is given to very different ſubſtances, namely, the *magiſtery of biſmuth*, and the waſhed *chalk* uſed for painting in water colors.

DCCXXXIX. WHITE-LEAD. This name is given to the white ruſt produced by expoſing lead to the vapors of vinegar. It is alſo called *ceruſs*. *See* Ceruss.

DCCXL. WINE. Chemiſts give the name of *wine* in general to all liquors that have become ſpirituous by fermentation. Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and other ſimilar liquors, are wines.

The principles and theory of the fermentation which produces theſe liquors are eſſentially the ſame. The more general principles we have explained under the article Fermentation. At the articles Beer and Hydromel may be found ſome peculiarities relative to theſe kinds of wines. In the preſent article we ſhall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the ſame time, we ſhall not neglect any thing relating to ſpirituous fermentation in general.

All vegetable and animal matters, which have a taſte ſweet, agreeable, and more or leſs ſaccharine, and which are nutritive, are ſuſceptible of the ſpirituous fermentation. Thus wine may be made of all the juices of plants, the ſap of trees, the infuſions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is poſſeſſed of the above-mentioned qualities; and, laſtly, it may be made of all ripe ſucculent fruits, which alſo are poſſeſſed of theſe qualities: but all theſe ſubſtances are not equally proper to be changed into a good and generous wine.

As the production of ardent ſpirit is the reſult of the ſpirituous fermentation, we may conſider that wine as eſſentially the beſt which contains moſt of this ſpirit. But of all ſubſtances ſuſceptible of the ſpirituous fermentation, none is capable of being converted into ſo good wine, as the juice of the grapes of France, or of other countries that are nearly in the ſame latitude, or in the ſame temperature. The grapes of hotter countries, and even thoſe of the ſouthern provinces of France, do indeed furniſh wines that have a more agreeable, that is, more of a ſaccharine taſte; but theſe wines, though they are ſufficiently ſtrong, are not ſo ſpirituous as thoſe of the provinces near the middle of France: at leaſt, from theſe latter wines the beſt vinegar and aqua vitæ are made. As an example therefore of ſpirituous fermentation in general, we ſhall deſcribe the method of making wine from the juice of the grapes of France.

This juice, when newly expreſſed, and before it has begun to ferment, is called *muſt*, and in common language *ſweet wine*. It is turbid, has an agreeable and very ſaccharine taſte. It is very laxative, and when drank too freely, or by perſons diſpoſed to diarrhæas, it is apt to occaſion theſe diſorders. Its conſiſtence is ſomewhat leſs fluid than that of water, and it becomes almoſt of a pitchy thickneſs when dried.

When the muſt is preſſed from the grapes, and put into a proper veſſel and place, with a temperature from ten or twelve degrees to fifteen or ſixteen, very ſenſible effects are produced in it, in a ſhorter or longer time, according to the nature of the liquor, and the temperature of the place. It then ſwells, and is ſo rarefied, that it frequently overflows the veſſel containing it, if this be nearly full. An inteſtine motion is excited among its parts, accompanied with a ſmall hiſſing noiſe and evident ebullition. The bubbles riſe to the ſurface, and, at the ſame time, is diſengaged a vapor which is probably of a phlogiſtic nature, and is ſo ſubtle and dangerous, that it is capable of killing inſtantly men and animals expoſed to it in a place where the air is not renewed. In its effects this vapor is ſimilar to that of burning charcoal. The ſkins, ſtones, and other groſſer matters of the grapes, are buoyed up by the particles of diſengaged air that adhere to their ſurface, are variouſly agitated, and are raiſed in form of a ſcum or ſoft and ſpongy cruſt that covers the whole liquor. During the fermentation this cruſt is frequently raiſed, and broken by the air diſengaged from the liquor, which forces its way through it: afterwards the cruſt ſubſides, and becomes entire as before.

Theſe effects continue while the fermentation is briſk, and at laſt gradually ceaſe: then the cruſt being no longer ſupported, falls in pieces to the bottom of the liquor. At this time, if we would have a ſtrong and generous wine, all ſenſible fermentation muſt be ſtopt. This is done by putting the wine into cloſe veſſels, and carrying theſe into a cellar or other cool place.

After this firſt operation, nature tends ſpontaneouſly to a kind of reſt, as is indicated by the ceſſation of the ſenſible effects of the ſpirituous fermentation; and thus enables us to preſerve a liquor no leſs agreeable in its taſte, than uſeful for its reviving and nutritive qualities when drank moderately.

If we examine the wine produced by this firſt fermentation, we ſhall find that it differs entirely and eſſentially from the juice of grapes before fermentation. Its ſweet and ſaccharine taſte is changed into one that is very different, though ſtill agreeable, and ſomewhat ſpirituous and piquant. It has not the laxative quality of muſt, but affects the head, and occaſions, as is well known, drunkenneſs. Laſtly, if it be diſtilled, it yields, inſtead of the inſipid water obtained from muſt by diſtillation with the heat of boiling water, a volatile, ſpirituous, and inflammable liquor called *ſpirit of wine*, or *ardent ſpirit*. This ſpirit is conſequently a new being, produced by the kind of *fermentation* called the *vinous* or *ſpirituous*. *See* SPIRIT (ARDENT).

As, on one ſide, the liquors ſuſceptible of the ſpirituous fermentation contain chiefly a ſweet oil rendered miſcible with water by means of an acid; and as, on the other ſide, the liquor produced by the ſpirituous fermentation is inflammable, but ſtill miſcible with water, and conſequently compoſed of a watery and inflammable principle; we may eaſily perceive, that the work of nature chiefly conſiſts in attenuating, dividing, and volatiliſing the oily parts of fermentable matters, and in combining theſe intimately with the watery principle. But by what mechaniſm does nature operate this change? In what does this attenuation of the oily part preciſely conſiſt? In what proportion is this oil, or only its inflammable principle, united with the watery principle in the compoſition of ardent ſpirit? Theſe are myſteries of nature that are ſtill entirely hid from us, and which we cannot eaſily explain. Without entering, therefore, into a ſpeculation concerning the production of ardent ſpirit, we ſhall proceed in the hiſtory of ſpirituous fermentation.

When any liquor undergoes the ſpirituous fermentation, all its parts ſeem not to ferment at the ſame time, otherwiſe the fermentation would probably be very quickly compleated, and the appearances would be much more ſtriking:

hence, in a liquor much diſpoſed to fermentation, this motion is more quick and ſimultaneous than in another liquor leſs diſpoſed. Experience has ſhewn, that a wine, the fermentation of which is very ſlow and tedious, is never good and very ſpirituous; and therefore, when the weather is too cold, the fermentation is uſually accelerated by heating the place in which the wine is made. A propoſal, which I think is a good one, has been made by a perſon very intelligent in economical affairs, to employ a greater than the uſual heat to accelerate the fermentation of wine, in thoſe years in which grapes have not been ſufficiently ripened, and when the juice is not ſufficiently diſpoſed to fermentation.

A too haſty and violent fermentation is perhaps alſo hurtful, from the diſſipation and loſs of ſome of the ſpirit: but of this we are not certain. However, we may diſtinguiſh, in the ordinary method of making wines of grapes, two periods in the fermentation, the firſt of which laſts during the appearance of the ſenſible effects above-mentioned, in which the greateſt number of fermentable particles do ferment. After this firſt effort of fermentation, theſe effects ſenſibly diminiſh, and ought to be ſtopped, for reaſons hereafter to be mentioned. The fermentative motion of the liquor then ceaſes. The heterogeneous parts that were ſuſpended in the wine by this motion, and which render it muddy, are ſeparated, and form a ſediment called the lees; after which the wine becomes clear: but although the operation be then conſidered as finiſhed, and the fermentation apparently ceaſes, it does not really ceaſe; and it ought to be continued in ſome degree, if we would have good wine. In this new wine a part of the liquor remains that has not fermented, and which does afterwards ferment, but ſo very ſlowly, that none of the ſenſible effects produced in the firſt fermentation are here perceived. The fermentation, therefore, continues ſtill in the wine, during a longer or ſhorter time, although in an imperceptible manner; and this is the ſecond period of the ſpirituous fermentation, which may be called the *imperceptible fermentation*. We may eaſily perceive, that the effect of this imperceptible fermentation is the gradual encreaſe of the quantity of ſpirit in wine. It has alſo another effect no leſs advantageous, namely, the ſeparation of a ſaline, acid, earthy matter, called *tartar*, from the wine. This matter is therefore a ſecond ſediment that is formed in the wine, and which adheres to the ſides of the containing veſſels. As the taſte of tartar is harſh and diſagreeable, it is evident that the wine, which, by means of the inſenſible fermentation, has acquired more ſpirit, and has diſengaged itſelf of the greateſt part of its tartar, ought to be much better and more agreeable; and for this reaſon chiefly, old wine is univerſally preferable to new wine.

But inſenſible fermentation can only ripen and meliorate the wine, if the ſenſible fermentation has regularly proceeded, and has been ſtopped in due time. We know certainly, that if a ſufficient time has not been allowed for the firſt period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles or cloſe veſſels in which the wine is put, and will occaſion effects ſo much more ſenſible, as the firſt fermentation ſhall have been ſooner interrupted: hence theſe wines are always turbid, emit bubbles, and ſometimes break the bottles, from the large quantity of air and vapors that are diſengaged during the fermentation. We have an inſtance of theſe effects in the white wine of Champagne, and in others of the ſame kind. The ſenſible fermentation of theſe wines is interrupted, or rather ſuppreſſed, that they may have this ſparkling quality. It is well known that theſe wines make the corks fly out of the bottles, that they ſparkle and froth when they are poured into glaſſes, and, laſtly, that they have a taſte much more lively and more piquant than wines that do not ſparkle; but this ſparkling quality, and all the effects depending on it, are only cauſed by a conſiderable quantity of air which is diſengaged during the confined fermentation which the wine has undergone in cloſe veſſels. This air, not having an opportunity of eſcaping, and of being diſſipated as faſt as it is diſengaged, and being interpoſed betwixt all the parts of the wine, combines in ſome meaſure with theſe, and adheres in the ſame manner as it does to thoſe mineral waters that are called ſpirituous, in which it produces nearly the ſame effects. When this air is entirely diſengaged from theſe wines, they no longer ſparkle, they loſe their piquancy of taſte, become mild, and even almoſt inſipid.

Such are the qualities that wine acquires in time, when its firſt fermentation has not continued ſufficiently long. Theſe qualities are given purpoſely to certain kinds of wine, to indulge taſte or caprice; but ſuch wines ought not to be daily drank. Wines for daily uſe ought to have undergone ſo compleatly the ſenſible fermentation, that the ſucceeding fermentation ſhould be inſenſible, or, at leaſt, exceedingly little ſenſible. Wine, in which the firſt fermentation has been too far advanced, is liable to worſe inconveniences than that in which the firſt fermentation has been too quickly ſuppreſſed; for every fermentable liquor is from its nature in a continual fermentative motion, more or leſs ſtrong, according to circumſtances, from the firſt inſtant of the ſpirituous fermentation, till it is compleatly putrefied: hence from the time of the completion of the ſpirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very ſlow and inſenſible when the wine is included in very cloſe veſſels, and in a cool place; but it does gradually advance, ſo that in a certain time the wine, inſtead of being meliorated, becomes at laſt ſour. This evil cannot be remedied, becauſe the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become ſour, can only conceal or abſorb this acidity by certain ſubſtances, as by alkalis and abſorbent earths. But theſe ſubſtances give to wine a dark-greeniſh color, and a taſte, which, though not acid, is ſomewhat diſagreeable. Beſides, calcareous earths accelerate conſiderably the total deſtruction and putrefaction of the wine. Calxes of lead, having the property of forming with the acid of vinegar a ſalt of an agreeable ſaccharine taſte, which does not alter the color of the wine, and which beſides has the advantage of ſtopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occaſion moſt terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil conſequences of lead, ſhould, for the ſake of gain, employ it for the purpoſe mentioned; but if there be any ſuch perſons, they muſt be conſidered as the poiſoners and murderers of the public.

If wine contains litharge, or any other calx of lead, it may be diſcovered by evaporating ſome pints of it to dryneſs, and melting the reſiduum in a crucible, at the bottom of which a ſmall regulus of lead may be found after the fuſion:

but an eaſier and more expeditious proof is by pouring into the wine ſome liquid liver of ſulphur. If the precipitate occaſioned by this addition of the liver be white, or only colored by the wine, we may know that no lead is contained: but if the precipitate be dark-colored, brown, or blackiſh, we may be certain that lead is contained.

The only ſubſtances that cannot abſorb or deſtroy, but cover and render ſupportable the ſharpneſs of wine, without any inconvenience, are ſugar, honey, and other ſaccharine alimentary matters; but they can ſucceed only when the wine is but very little acid; and when an exceeding ſmall quantity only of theſe ſubſtances is ſufficient to produce the deſired effect; otherwiſe the wine would have a ſweetiſh, tart, and not agreeable taſte.

From what we have ſaid concerning the aceſcency of wine we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with ſour wine but to ſell it to vinegar-makers, as all honeſt wine-merchants do. We may obſerve, that the firſt ſenſible fermentation having been too far advanced, is not the only cauſe of the acidity of wine, but that heat alſo is capable of producing the ſame effect. Thus wine, which might have been long preſerved in a cool place, very quickly becomes ſour, when placed in a bad cellar; and even as the beſt cellars have during winter a degree of heat much ſuperior to that of the atmoſphere, it would be very proper, when wine diſpoſed to become ſour is to be preſerved, to bring it from the cellar in the beginning of winter, and leave it expoſed to the air during all that ſeaſon.

Wine is alſo liable to other changes; as, to become ropey and mucilaginous, by the continuance of the fermentative motion: but we cannot proſecute theſe details in a work of this kind. Beſides, the ſpirituous fermentation and its conſequences ſtill require a further examination, which we hope will be performed in a ſatisfactory manner, ſince ſeveral Academies, ſenſible of the importance of the ſubject, have offered prizes for diſcoveries relative to it. All that we can at preſent ſay is, that the fundamental principles from which we may deduce a more accurate knowledge on this ſubject, may be diſcovered by determining with what degree of heat, and during what time, the firſt ſenſible fermentation of muſt ought to be promoted, that the moſt ſpirituous and beſt-keeping wine may be obtained. I confeſs that this object is very extenſive, and very difficult to be known in a general manner, conſidering how variable theſe things are, and what differences, perhaps greater than we now imagine, there ought to be, according to the nature of the muſt, which varies exceedingly in different countries, and at different times. Experience and obſervation have already inſtructed makers of wine in many things relative to this ſubject; but much yet remains to be determined, which is not within the reach of ordinary country-people, or even of the proprietors of the great vine-yards.

Wine, and the matters produced from wine, as brandy, ſpirit of wine, vinegar, lees of wine, tartar, are greatly and extenſively uſeful. The lees of wine are employed in the manufacture of hats. Theſe lees, and alſo tartar by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali. *See the articles* AQUA VITÆ, SPIRIT *of* WINE, TARTAR, *and* VINEGAR.

Wine has been preferred in all times and in all countries to every other alimentary liquor. We may ſay in general, that it is good and ſalutary when taken in ſmall quantities, and that it is pernicious when drank habitually, and in too large quantities. Wine becomes then a true ſlow poiſon, which is ſo much more dangerous, as it is more agreeable. But if we obſerve more particularly the effects of wine, we ſhall perceive very great differences depending on different conſtitutions. Some perſons drink habitually large quantities of pure wine, without any ſenſible inconvenience, or diſeaſe, or ſhortening their lives: but, on the contrary, many others do alſo entirely deſtroy their health, and ſhorten their lives, by an habitual uſe of wine even in ſmall quantity, and mixed with water. Although it is always more ſafe and prudent for every perſon to drink little of it habitually, this moderation is more indiſpenſably neceſſary to thoſe whoſe conſtitutions wine does not ſuit.

As the diſeaſes conſequent upon the too free uſe of wine come gradually and inſenſibly, ſometimes even during many years, ſeveral perſons, eſpecially men, otherwiſe very ſober and attentive to health, are every day deceived upon this article, drinking more wine than is ſuitable to their conſtitution, and gradually ruining their health without knowing the cauſe. It is therefore a matter of importance to ſhew the ſigns by which wine may be known to be hurtful. We may know that wine does not ſuit a perſon, when, after drinking moderately of it, his breath acquires a vinous ſmell; when it occaſions ſour belchings and ſlight pains in the head; and when, after drinking it more copiouſly than uſual, it produces ſtupefaction, nauſea, and drunkenneſs, eſpecially when this drunkenneſs is of the moroſe, peeviſh, quarrelſome, and iraſcible kind. Unhappy is that perſon who ſuffers theſe effects from wine, and notwithſtanding contracts and perſiſts in the habitual uſe of it. Theſe imprudent perſons do never fail of coming to a miſerable death, preceded by languor, and premature; their common age being about fifty years, or a little more. The diſeaſes to which they are moſt ſubject are obſtructions in the liver, in the meſenteric glands, and in other abdominal viſcera, which are almoſt always ſucceeded by an incurable dropſy. Thoſe who digeſt wine well, do not ſuffer, or much leſs ſenſibly, the above-mentioned effects of drinking it. Their drunkenneſs is accompanied with vivacity and joy. Such perſons ſeldom die of the obſtructions and dropſy above-mentioned: but wine is nevertheleſs ſo much more dangerous to them, that as they ſuffer none of the diſagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this claſs generally live ſomewhat longer than the former; but their conſtitution generally changes before ſixty years of age; and the inheritance of their old age is either a ſevere gout or palſy, ſtupidity, imbecillity, or an accumulation of theſe diſeaſes.

We need not mention that the too frequent uſe of brandy, ratafia, and of other ſpirituous liquors is ſtill much more pernicious and fatal than of wine.

Wine is uſed in medicine as a vehicle in the compoſition of many internal and external remedies. As wine is compoſed of an ardent ſpirit, water, extractive ſaponaceous matter, and acid of tartar, it may be very uſefully employed for the extraction of almoſt all the proximate principles, and conſequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be conſidered as being more compleat than thoſe made with water: but phyſicians who preſcribe theſe extracts ought to remember that, beſides the principles of the vegetables, they alſo contain the extractive part of wine, that is, all the principles of wine, excepting the ardent ſpirit, which is too volatile to remain in an extract.

As wine, when good, may be preſerved during a long time, ſeveral medicinal wines preſcribed in diſpenſatories are kept in the ſhops of apothecaries. Such are the aſtringent, antiſcorbutic, febrifugal wines of the Peruvian bark, of wormwood, chalybeate wine, and others. In many caſes, as in ſeveral chronical diſeaſes, where tonic, cordial, fortifying and exciting remedies are indicated, phyſicians prefer the uſe of wine to water, as a vehicle for the infuſion of purgative, aperitive, and other medicinal ſubſtances.

DCCXLI. WOAD. (z)

(z) Woad. Dr. Lewis in a note to his edition of Neuman's Chemical Works gives the following account of woad.

Woad, iſatis, glaſtum, is a plant with long green leaves; the lower ones narrow at both ends; thoſe which grow upon the ſtalk are broad at bottom like an arrow-head. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the ſeeds. It grows wild in ſome parts of France, and on the coaſts of the Baltic Sea: the wild woad, and that which is cultivated for the uſe of dyers, appear to be the ſame ſpecies of plant. The preparation of woad for dying, as practiſed in France, is minutely deſcribed by Aſtruc, in his Memoirs for a Natural Hiſtory of Languedoc. The plant puts forth at firſt five or ſix upright leaves, about a foot long and ſix inches broad: when theſe hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much reſembling the oil or tan-mills, and ground into a ſmooth paſte. If this proceſs was deferred for ſome time, they would putrefy, and ſend forth an inſupportable ſtench. The paſte is laid in heaps, preſſed cloſe and ſmooth, and the blackiſh cruſt, which forms on the outſide, reunited if it happens to crack: if this was neglected, little worms would be produced in the cracks, and the woad would loſe a part of its ſtrength. After lying for fifteen days, the heaps are opened, the cruſt rubbed and mixed with the inſide, the matter formed into oval balls, which are preſſed cloſe and ſolid in wooden moulds. Theſe are dried upon hurdles: in the ſun, they turn black on the outſide; in a cloſe place, yellowiſh, eſpecially if the weather be rainy: the dealers in this commodity prefer the firſt, though it is ſaid the workmen find no conſiderable difference betwixt the two. The good balls are diſtinguiſhed by their being weighty, of a pretty agreeable ſmell, and when rubbed, of a violet colour within. For the uſe of the dyer, theſe balls require a further preparation: they are beat with wooden mallets, on a brick or ſtone floor, into a groſs powder; which is heaped up in the middle of the room to the height of four feet, a ſpace being left for paſſing round the ſides. The powder, moiſtened with water, ferments, grows hot, and throws out a thick fetid fume. It is ſhovelled backwards and forwards, and moiſtened every day for twelve days; after which it is ſtirred leſs frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only browniſh tinctures, of different ſhades, to water, to rectified ſpirit of wine, to volatile alkaline ſpirits, and to fixed alkaline lixivia: rubbed on paper, it communicates a green ſtain. On diluting the powder with boiling water, and after ſtanding ſome hours in a cloſe veſſel, adding about one twentieth part of its weight of lime newly ſlaked, digeſting in a gentle warmth, and ſtirring the whole together every three or four hours, a new fermentation begins, a blue froth ariſes to the ſurface, and the liquor, though it appears itſelf of a reddiſh color, dyes woollen of a green, which, like the green from Indigo, changes in the air to a blue. This is one of the niceſt proceſſes in the art of dyeing, and does not well ſucceed in the way of a ſmall experiment.

Aſtruc propoſes the manufacturing of freſh woad leaves in Europe, after the ſame manner as the Indigo plant is manufactured in America;

DCCXLII. WOLFRAM. (*a*)

DCCXLIII. WOOL (PHILOSOPHIC). This is a name given by ancient chemical or alchemical authors to flowers of zinc. *See* FLOWERS *of* ZINC.

DCCXLIV. WORMWOOD. (*b*)

America; and thus preparing from it a blue fecula ſimilar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtleſs be accompanied with ſome advantages, though poſſibly, woad ſo prepared might loſe thoſe qualities which now render it, in a large buſineſs, preferable on ſome accounts to indigo, as occaſioning greater diſpatch when once the vat is ready, and giving out its color leſs haſtily, ſo as to be better fitted for dying very light ſhades.

(*a*) WOLFRAM, *Spuma lupi*, is a very refractory mineral of a black or duſky color, cryſtallized in form of cubes, ſtriæ, or other determinate ſhape, and conſiſting of ſhining plates. Its appearance is ſimilar to the ore of tin, called tin-grains or cryſtals of tin: and it is frequently found in tin-mines. It is ſo hard that it can ſtrike ſparks from ſteel. When powdered, it is red. Wallerius conſiders it as an ore of iron mineraliſed by arſenic, which ſometimes contains tin. According to Cronſtedt, it is a kind of magneſia or mangeneſe, containing a ſmall portion of iron and of tin.

(*b*) WORMWOOD. The leaves of wormwood are intenſely bitter, and have a ſtrong ſmell, ſomewhat of the aromatic kind. They yield in diſtillation a conſiderable quantity of eſſential oil of a dark greeniſh color poſſeſſing the whole of their ſmell, the bitter matter remaining in the extract. *Neuman.*

Z.

DCCXLV. ZAFFRE, *or* SAFFRE. Zaffre is the reſiduum of cobalt, after the ſulphur, arſenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore a kind of calx of cobalt, of a grey or reddiſh color. The uſe of cobalt is to produce a very fine blue color, when it is melted with fuſible and vitrifiable matters.

This blue color produced by the vitrification of zaffre proceeds from the earth or calx of a ſemi-metallic ſubſtance contained in cobalt, called by chemiſts, *regulus of cobalt*. This is proved by melting zaffre with a reducing flux, like any other roaſted ore; by which means the above-mentioned ſemi-metallic regulus of cobalt will be obtained. The ſcoria in this fuſion has alſo a blue color, which proceeds from a portion of the calx of this regulus that is not reduced, but is vitrified along with the ſcoria.

The calx therefore or metallic earth of the regulus of cobalt is the ſole cauſe of the blue color produced by zaffre. But as the quantity of regulus contained in cobalt is variable, therefore ſome zaffres furniſh more blue than others. The heterogeneous, fixed matters contained in cobalts, contribute, according to their quantity, not only to the greater or leſs intenſity of the blue color, but alſo to its luſtre and beauty. For which reaſon thoſe who manufacture zaffre from cobalt make frequent eſſays of the roaſted ore by mixing it with vitreous matters to diſcover the intenſity and beauty of the blue color.

Good cobalts calcined would form too deep a blue, and almoſt a black glaſs, if they were not previouſly mixed with a certain quantity of vitreous fritt. In the manufacture of zaffre, therefore, the calx of cobalt, the ſtrength of which has been previouſly determined by Eſſays, is mixed with ſuch a quantity of ſand, or of powdered flints and quartz, that with the addition of ſome ſaline flux, a deep blue glaſs may be formed.

The zaffre that is commonly ſold, and which comes from Saxony, is a mixture of calx of cobalt with ſome vitrifiable earth, as we have ſaid. It is of a grey color, as all calxes of cobalt are before vitrification. Some zaffres are dearer than others, according to the intenſity of the color which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the ſurface of the pieces of ware, upon which it is applied together with ſome ſaline flux, previouſly to the baking or glazing, that the ſame fire may alſo vitrify this coloring material.

The blue of zaffre is the moſt ſolid and fixed of all the colors that can be employed in vitrification. It ſuffers no change from the moſt violent fire. It is ſucceſsfully employed to give ſhades of blue to enamels, and to the cryſtal-glaſſes made in imitation of ſome opake and tranſparent precious ſtones, as the lapis lazuli, the turquois, the ſaphire, and others of this kind. *See the articles* AZURE, COBALT, INK (SYMPATHETIC), *and* SMALT.

DCCXLVI. ZEOLITES. (*c*)

DCCXLVII. ZINC. Zinc is a ſemi-metal, of a brilliant white color, approaching to blue. It is the leaſt brittle of the ſemi-metals; and when well furniſhed with phlogiſton, which may be effected by treating it with inflammable matters in a cloſe veſſel, it poſſeſſes a ſemi-ductility, by means of which it may be flattened into thin plates. (*d*).

This property, joined to its hardneſs, which is alſo conſiderable, renders it incapable of being pulveriſed like the other ſemi-metals; therefore, when it is required in a divided ſtate, it muſt be melted and granulated, or filed, like metals.

(*c*) ZEOLITES. This name is given by Mr. Cronſtedt to a ſtone deſcribed by him in the *Tranſactions of the Academy of Sciences at Stockholm for the year* 1756, the peculiar properties of which have induced that mineralogiſt to conſider it as forming a diſtinct order of earths, called *zeolites*. The properties of this ſtone or claſs of earths, are the following.

1. It is a little harder than the fluors, and calcareous ſpars. It may be ſcratched by ſteel, from which it does not elicit ſparks.

2. It may eaſily be melted by heat without addition, into a white frothy ſlag, which not without great difficulty can be rendered ſolid and tranſparent. Cryſtallized zeolites, when melted, boils, as borax does.

3. It may be diſſolved in the fire more eaſily by mineral alkali than by borax or by the fuſible ſalt of urine.

4. It does not effervеſce with the fuſible ſalt of urine, as calcareous ſtones do; nor with borax, as gypſeous ſtones do.

5. It diſſolves very ſlowly, and without efferveſcence, in acids, as in oil of vitriol, and ſpirit of nitre. When concentrated vitriolic acid is poured on powdered zeolites, a heat ariſes, and the powder is changed into a gelatinous maſs.

6. In the very moment of fuſion it gives a phoſphoric light.

Zeolites has been found only in an indurated ſtate. It is either, 1. conſiſting of particles of no determinate form; or, 2. *ſparry*; or, 3. *cryſtallized*.

The zeolites that conſiſts of particles of no determinate form, is either *pure*, and white; or it is *mixed with ſilver and iron*; which latter kind is of a blue color, and is commonly called lapis lazuli. *See* LAPIS LAZULI.

The *ſparry zeolites* reſembles calcareous ſpar, but is more brittle. This is of a light red, or orange color.

Cryſtallized zeolites. Groupes of cryſtals of zeolites are found in form of white or yellow balls conſiſting of many pyramids the apices of which unite in the center; or of white priſms with truncated angles; or of white capillary cryſtals.

Zeolites has in the fire nearly the ſame properties as boles have. See *Stockholm Tranſ.* for the year 1755, and *Cronſtedt's Mineralogy*, §. 108.

(*d*) Zinc when broken appears of many flat, ſhining plates, or facets, which are larger when ſlowly than when haſtily cooled. When

The ſpecific gravity of zinc is nearly the ſame as that of regulus of antimony; that is to ſay, it loſes in water about a ſeventh part of its weight. (*e*)

This ſemi-metal is not eaſily calcined or covered with ruſt by the action of the air and of water: in this reſpect it reſembles tin. It is leſs fuſible than tin and lead, as it does not melt till it is almoſt red-hot. When it only ſuffers the degree of heat neceſſary for its fuſion, its ſurface is calcined and reduced to a grey calx, eaſily reducible, like thoſe of tin and other fuſible metallic ſubſtances. But when it is expoſed to heat approaching to a white-heat, it flames; and during this inflammation it exhibits a very beautiful and ſtriking appearance. The flame of zinc is infinitely more lively, more luminous, and more brilliant, than the flame of any other inflammable matter. It is of a dazzling white, and is ſo vivid as to be inſupportable to the ſight. This flame cannot be attributed to any ſulphur which might be ſuppoſed to remain united with the zinc, for we ſhall ſee that this ſemi-metal cannot be united with ſulphur; but merely to phlogiſton, which in zinc is very combuſtible. This ardent deflagration is a moſt ſenſible proof of the preſence of this principle in metallic ſubſtances.

The deflagration of zinc is ſo violent that the earth of this ſemi-metal although naturally very fixed, like that of almoſt all metallic ſubſtances, is raiſed in form of white ſmoke, which is condenſed, and floats in the air like light flocks. Theſe are called *flowers of zinc*, and *philoſophical wool. See* FLOWERS *of* ZINC.

Zinc being the moſt combuſtible of all metals, detonates more violently than any other metal with nitre. From the whiteneſs and brilliancy of the flame produced by this detonation, it has been employed with very good effect as an ingredient in compoſitions for fireworks.

All acids are capable of diſſolving zinc. Six parts of good vitriolic acid diluted with an equal weight of water can diſſolve entirely, by help of gentle heat, one part of zinc. The neutral ſalt reſulting from this ſolution is cryſtallizable; and is called *white vitriol*, or *vitriol of zinc*. See a deſcription of the method in which this vitriol is made at Goſlar, at the article SMELTING *of* ORES.

Zinc has a ſtrong affinity with vitriolic acid. It appears to have a ſtronger than any other metallic ſubſtance: for by means of this ſemi-metal, the vitriols of copper and of iron may be decompoſed. It ſeparates theſe metals from the vitriolic acid, to which it unites and forms a white vitriol. But what is remarkable, is, that notwithſtanding this great affinity of zinc with vitriolic acid, the vitriol of zinc is decompoſed, and its acid ſeparated by leſs heat than the martial vitriol, as Junker affirms in the firſt volume of his *Conſpectus Chymiæ*. If this experiment ſucceeds, as probably it does, we muſt refer the cauſe of it to the particular ſtates of the inflammable principle in zinc and in iron. All the properties of theſe two metallic ſubſtances ſhew that they abound in phlogiſton, and therefore vitriolic acid unites with them preferably to any other. But, at the ſame time, this phlogiſton is in theſe metals much

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When heated, it is very brittle. Like tin, it makes a crackling noiſe when it is bent.

(*e*) According to Muſchenbroek's table of ſpecific gravities, Indian zinc is to water as 7.2401 to 1: and zinc of Goſlar is as 7.215 to 1.

unfolded and weakly combined, which is undoubtedly the cauſe, that the neutral ſalts which they form with the vitriolic acid may be decompoſed by the action of fire. For, the phlogiſton of theſe metals adhering but ſlightly to their earth, may be more eaſily combined with the vitriolic acid, and by converting this acid into volatile vitriolic, or ſulphureous acid, may ſtill more facilitate its ſeparation.

But as the inflammable principle of zinc is more abundant, and more ſlightly engaged than that of iron, zinc ought to unite with vitriolic acid preferably to iron, and the vitriol of zinc ought to be decompoſed by fire more eaſily than the vitriol of iron.

When white vitriol is diſtilled by violent heat, nearly the ſame phenomena happen as when martial vitriol is diſtilled. Towards the end of the diſtillation of white vitriol, a vitriolic acid ariſes, dephlegmated, tho' very ſulphureous. This acid added to common concentrated vitriolic acid produces as much heat as water would have done, if added to the ſame concentrated acid.

Zinc may alſo be diſſolved in the nitrous and marine acids. But this latter acid does not touch a black matter which ſeparates from the ſemi-metal during its ſolution. M. Hellot who has examined the phenomena of this ſolution as well as thoſe of the ſolutions of this ſemi-metal in the vitriolic and nitrous acids, has aſcertained that this black matter is not mercury, and that it cannot even be reduced into a metallic ſubſtance. (*f*)

Zinc may be allayed or mixed with all metallic ſubſtances excepting *biſmuth* (*g*). If theſe two metals be melted together, they will be found ſeparately at the bottom of the crucible, the zinc being the lighter lying above the biſmuth. The allay of zinc with iron is effected difficultly; but that with copper ſucceeds well, and is much uſed, on account of a ſingular property which zinc has of uniting with copper in a conſiderable proportion; as, for inſtance, one part of zinc to four or three parts of copper, without much diminution of the ductility of the copper. Zinc added to copper renders this metal leſs ſubject to ruſt, and gives to it a yellow color reſembling that of gold. This copper ſo allayed with zinc is called *braſs* or *latten*. *See* BRASS.

The color of braſs approaching to that of gold, has induced chemiſts to ſearch for the means of communicating to copper the true color of gold. And they have actually ſucceeded in the compoſitions or allays called *tombacs*, *ſimilor*, *Pinchbeck*, and *Prince's metal*. Beccher had ſaid, that equal parts of copper and zinc mixed together gave a color to the touch-ſtone like that of the gold from the Rhine. Stahl remarks that the proportion of zinc mentioned by Beccher is too great, but does not determine what this proportion ought to be. Since that time, the due proportion has been inveſtigated, and ſeveral fine imitations of gold have been found. The Engliſh were the firſt who ſucceeded, and they called their invention *Prince's metal*, or *Prince Rupert's metal*.

More perfect imitations of gold have been lately made by Lacroix and Leblanc; each of whom produced a metallic mixture, one of which excelled in

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(*f*) Neuman ſays, that this black matter was ſeparated during the ſolution of this ſemi-metal in vitriolic and in marine acids, and that two or three days afterwards it was re-diſſolved.

(*g*) It cannot be allayed with the ſemi-metal called nickel.

ductility, and the other in color. But theſe artiſts have not revealed their proceſſes. M. Geoffroy has made with this view many experiments, the detail of which may be ſeen in the Memoirs of the Academy for the year 1725. It appears from theſe experiments, that the remark made by Stahl, that an equal quantity of zinc is too much, was very juſt, with regard to the ductility of the allay, but that equal quantities produced the fineſt color. We may nevertheleſs obſerve, that as copper requires a ſtrong heat to keep it fuſed, and as zinc is very volatile, theſe two ſubſtances cannot be mixed without loſs, both of the copper, ſome of which is calcined, and of the zinc, a part of which is burnt and diſſipated in fumes. Hence it follows, that after the mixture is made, the proportion betwixt the two metals is not certain. After ſome experiments which I have ſeen, I can ſcarcely be perſuaded that a fine-colored mixture can be obtained, and particularly of a deep enough yellow, if as much zinc as copper actually remained. (*b*)

We muſt alſo obſerve, that in order to have a fine-colored and ductile metallic mixture of this kind, it is neceſſary, according to Mr. Cramer, to uſe the pureſt zinc. The ſame author ſhews the means of purifying it, and of aſcertaining its purity. This method is founded on the remarkable property which zinc has of being incapable of uniting with ſulphur (*i*). Therefore, to purify this ſemi-metal from the allay of other metals, it is neceſſary to throw upon it, when melted in a large crucible, ſuet and ſulphur alternately, and the latter in larger quantities than the former. If the zinc is pure, the ſulphur burns freely on its ſurface; but if it is allayed, the ſulphur combines with the other metals, and forms with them a kind of ſcoria which muſt be taken off. This alternate projection of ſuet and ſulphur upon zinc is continued till the ſulphur be burnt on the ſurface of the melted zinc, without forming any ſcoria; the zinc thus purified, may be ſucceſsfully employed for making of braſs or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr. Gellert's table, in the following order: Copper, iron, ſilver, gold, tin, and lead. This laſt is ſaid to be only partly miſcible with zinc. Sulphur might be ſo placed in this table, as to ſhew its incapacity of uniting with zinc.

The chief uſe of zinc is as an ingredient in the compoſition of braſs. M. Malouin, who, in his Memoirs upon Zinc, has mentioned ſeveral properties of this ſemi-metal which he finds analogous to thoſe of tin, relates in theſe Memoirs ſome experiments which he made with ſucceſs, in order to ſubſtitute zinc for tin, in the operation upon iron plates, &c. called *tinning*. As all the properties

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(*b*) One part of zinc is ſaid to be capable of deſtroying the ductility of a hundred parts of gold. An allay of equal parts of zinc and gold is very hard, white, capable of receiving a fine poliſh, and not ſubject to ruſt or tarniſh: hence it is propoſed by Mr. Malouin as a good material for making ſpecula of teleſcopes. Zinc gives hardneſs to tin, and is therefore added in ſome compoſitions for making pewter.

(*i*) Mr. Cramer ſays that zinc does not eaſily unite with ſulphur, but that if it remains long in a moderate fire, and be covered over with ſulphur at ſeveral times, and continually ſtirred with a poker, it will be at laſt changed into a very brittle, dark-colored ſubſtance. I ſuſpect that the iron of the poker contributed to this union of zinc with ſulphur, for I have never been able to unite ſulphur with pure zinc, when I ſtirred them with a tobacco-pipe.

of this ſemi-metal are not yet diſcovered, it may perhaps be hereafter found applicable to other uſes. (*k*)

(*k*) Some authors, as Wallerius and [illegible]ſtedt, ſay, that filings of zinc are attr[illegible] magnets. I have not been able to [illegible] this property.

Zinc unites more ſtrongly to aci[illegible] any other metal, and even ſome earths. Pott ſays, that it precipitates the earth[illegible] from a ſolution of alum; and that zinc cannot be precipitated from aqua fortis by crabs-eyes. He alſo ſays, that it may be precipitated by volatile alkali, but that this precipitate is quickly re-diſſolved.

The ſame author ſays, that zinc, by being converted into flowers, acquires an additional weight, equal to $\frac{1}{10}$th part of the ſemi-metal employed.

Mr. Malouin relates, that zinc being melted ſix times, and the fuſion continued 15 hours each time, it became more and more hard, brittle, unfuſible, and uncalcinable. He ſays, that its color became grey after the ſecond fuſion, brown after the third, black after the fourth, blue like a ſlate after the fifth, and a clear violet-color after the ſixth.

Concerning the ores and eſſay of ores of zinc, *ſee* ORES *of* ZINC; and concerning the methods of extracting large quantities of this ſemi-metal from its ores, *ſee* SMELTING *of* ORES, and PLATE II. *Fig.* 15, and 22, with the explanations.

FINIS.

CORRECTIONS AND ADDITIONS.

PAGE 2. *Notes, column ſecond, line fourth.* Inſtead of, “ them with a certain “ quantity of water,” read, “ concentrated acids with a certain quantity “ of water or of ice.”

Page 3. *Notes, column firſt, line* 14. Inſtead of, “ they,” read, “ moſt, if “ not all of them, when much concentrated.”

Ibid. col. 2, *line* 31. Inſtead of, “ of ſolid acid in each neutral ſalt,” read, “ that “ each neutral ſalt retains of the acid liquor employed in its preparation.”

Page 4. *Notes, col.* 1, *line* 4. Inſtead of “ ſhall,” read, “ ſhould.”

Ibid. line 8. Inſtead of, “ Hence we may perceive, &c.” *to the end of the ſentence,* read, “ But as a leſs quantity of acid was ſaid to have been actually employed, “ Mr. Homberg's alkali muſt have contained a leſs quantity of fixable air than “ we have ſuppoſed. But as we do not know the preciſe quantity of that air, “ nor the degree of dryneſs of his alkaline ſalt, we cannot from his experiments “ aſcertain the quantity of pure, dry, cauſtic alkali, contained in any of the “ neutral ſalts produced; nor can we determine how much of the acid liquor “ employed was retained in thoſe neutral ſalts after they had cryſtallized.”

Page 9. *Notes, col.* 2. *line* 8. Inſtead of, “ but not volatile alkali,” read, “ but it does not render volatile alkali ſoluble in ſpirit of wine.”

Page 33. *Note* (*b*), *line* 1. Inſtead of, “ term,” read, “ name.”

Ibid. Notes, col. 2, *line* 1. Inſtead of, “ this,” read, “ his.”

Page 34. *Notes, col.* 1, *line penult.* Inſtead of, “ combined,” read, “ uncombined.”

Page 35. *Notes, col.* 2. After the 28th line add, “ Dr. Macbride ſhews, that the “ air extricated from fermenting and putrefying ſubſtances is capable of combining with cauſtic alkalis, and with quicklime, and of rendering theſe mild. “ This air is therefore probably of the ſame kind as the air uſually combined “ with alkaline ſubſtances.”

Page 37. *Notes, col.* 1. After the ſecond line, add, “ Concerning the fixable “ air contained in *mineral waters,* and its power of *diſſolving calcareous earth,* “ and *iron* contained in theſe waters, *ſee the article* WATERS (MINERAL), *and* “ *a Note ſubjoined.*”

Page 40. Add the following *note,* referring to the article ALKALESCENT. “ This word ſignifies the tendency of bodies to become alkaline; and cannot “ be properly applied to ſignify a ſlight degree of alkaline quality.”

Page 49. *Notes, col.* 1, *line* 11. Inſtead of, “ in ordinary diſtillations,” read, “ in the ordinary method of diſtilling wood, together probably with ſome of “ its more fixed parts.”

Page 55. *Notes, col.* 2, *line* 1. Inſtead of " this ſalt to," read, " the mineral to " the."

Page 62. *Notes, col.* 2, *line* 2. Inſtead of " by their different denſities," read, " by fuſion, according to their different denſities, that is, the heavier metal " ſinking below the lighter."

Ibid. line 25. Inſtead of " by their different denſities," read, " by means of " their different denſities."

Page 73. *Notes, col.* 1, *line* 9. Inſtead of " earth," read, " ſubſtance."

Ibid. col. 2, *line* 10. Inſtead of " The ſame," read, " An equal."

Page 75. *Notes, col.* 2, *line* 2. Dele " Hence."

Ibid. At the end of the note (*i*) add, " But as mercury has been found to riſe " to a leſs height in barometrical tubes of iron than in thoſe of glaſs, have " we not reaſon to believe that theſe metals poſſeſs a power of repelling each " other? *See the Hiſt. de l'Acad. Roy. de Sciences*, 1706."

Page 91, *line* 15. Inſtead of " flux," read, " reſolvent."

Page 99. *Notes, col.* 2. *laſt line.* Inſtead of " cocoa," read, " coco."

Page 117. Inſtead of the paragraph beginning thus, " Some authors re- " commend, &c." read the following paragraph, as it is altered by the Author of the Dictionary.

" Several Chemiſts, amongſt whom is Mr. Pott, have believed that the " ſolution of biſmuth, which when well ſaturated, may be precipitated " by water, could not be precipitated by means of the marine acid, as thoſe " of lead and ſilver may, and conſequently that a corneous biſmuth could not " be formed. But Mr. Rouelle, in his Memoir upon Salts, [*ſee Mem. de " l'Acad. des Sc.* 1754.] ſays, that after having precipitated from a well ſatu- " rated ſolution all the biſmuth that he could by means of water, he obtained " a new precipitate by adding to the remaining liquor an equal quantity of " ſaturated ſolution of ſea-ſalt, and by gradually mixing with theſe a quantity " of common water equal to four times the quantity of the two ſolutions. " This ſecond precipitate is conſidered by Mr. Rouelle as a corneous biſmuth.

" If this be the caſe, biſmuth reſembles lead in many of its properties, as " Mr. Geoffroy the Younger has ſhewn in the Memoirs of the Academy of " Sciences. Accordingly, ſome chemiſts have called biſmuth, the *lead of the " ſemi-metals.*"

Page 124. Inſtead of the paragraph beginning thus, " A chemiſt of Berlin " having, &c." read the following paragraph, as it is altered by the Author " of the Dictionary.

" Stahl relates in his *Three Hundred Experiments*, &c. No. 231, the manner " in which this blue matter was diſcovered. He ſays, that a manufacturer of " colors, called *Dieſbach*, who uſually prepared a lake of cochineal by mixing a " decoction of this ſubſtance with alum and green vitriol, and by precipitating " the mixture with a fixed alkali, being one day in want of fixed alkali, for " this purpoſe borrowed from *Dippel*, in whoſe laboratory he worked, ſome " ſalt of tartar, from which that chemiſt had ſeveral times diſtilled the animal " oil called *oil of Dippel*, and obſerved that the lake precipitated by means " of this alkali, inſtead of being red, was of a fine blue color. Dippel, to whom " Dieſbach related this appearance, perceived that it muſt have been cauſed " by his alkali, and attempted to produce the ſame effects by giving the

" ſame quality to fixed alkali by an eaſier proceſs. His attempts ſucceeded, " and from that time Pruſſian blue has been prepared."

Page 131. *Notes, col.* 2. *line penult.* Inſtead of " in," read, " of."

Page 138. *line* 20. Inſtead of " cacao, butter," read, " cacao-butter."

Ib. line 34. Dele " made."

Page 142, *line* 36. Inſtead of " that," read, " why."

Page 151, *line* 37. Inſtead of " ferruginous and ſulphureous," read, " ferruginous, ſulphureous."

Page 181. *Notes, col.* 2. *line* 4. Inſtead of, " after a red heat has been gradually applied," read, " after heat has been gradually applied till the crucibles become red."

Page 216. *Notes, col.* 1, *line* 12. dele " alſo."

Page 226. *Notes, col.* 1. *line* 22. Inſtead of the ſentence beginning with, " If " we mean by *element*, &c." read the following ſentence: " But if we ſhould " call every ſubſtance an *element* which we cannot analyſe, then certainly many " other ſubſtances beſides the above-mentioned four might be enumerated " as elements."

Page 253. Add the following *note*, referring to the *ſixth line.*

" The method employed by Mr. Beaumé for obtaining a marine ether, " namely, by uniting the vapors of ſpirit of wine with thoſe of marine acid, " has been ſucceſsfully attempted by *Mr. Woulfe.* This ingenious chemiſt " condenſed the united vapors of the ſpirit of wine, and of the marine acid, by " making them paſs from the receiver through a tube into ſpirit of wine contained in a bottle, and by making thoſe which were not thus condenſed paſs " through another tube into more ſpirit of wine contained in another bottle. " By diſtilling and cohobating with ſlaked lime the liquors in the receiver, and " in the two above-mentioned bottles, he obtained a very ſubtle and penetrating ether. *See a deſcription of the apparatus employed by Mr. Woulfe, and " many curious particulars concerning diſtillation, in the Philoſophical Tranſactions, Vol.* LVII."

Page 254. Add the following *note*, referring to the *ſeventeenth line.*

" *Mr. Woulfe* deſcribes an apparatus by which nitrous ether may be expeditiouſly obtained by diſtillation; with the heat only occaſioned by mixing together " the nitrous acid and the ſpirit of wine. This diſtillation is performed in a " matraſs with a high neck, to which is fitted a head, with a ſpout, communicating with the receiver by means of a long tube. Thoſe vapors which are " not condenſed in this receiver are conveyed from thence through a bent " tube into ſpirit of wine contained in a bottle; and if any vapors paſs uncondenſed through this ſpirit of wine, they are conveyed, through another bent " tube, into more ſpirit of wine contained in another bottle. The liquor " collected in the receiver, being ſlowly rectified with ſlaked lime, furniſhes " very fine ether. The ſpirit of wine in which the vapors were condenſed " contains ſo much ether, that this fluid may be ſeparated from the ſpirit by " adding water. This ſpirit of wine is, by the operation, converted into very " good dulcified ſpirit of nitre. *See the Phil. Tranſ. Vol.* LVII.

Page 276. *Notes, col.* 1. *line* 39. Inſtead of, " when the flame has a conſiderable diameter, as of a foot or eighteen inches, and," read, " when a

" vapor of a conſiderable diameter, as of a foot or eighteen inches, is kindled,
" and the combuſtion"

Page 278. *Notes, col.* 2. *line* 4. Inſtead of the ſentence beginning, " They
" are alſo convertible, &c." read, " By means of fixed alkali they may be fuſed
" and vitrified: and when the quantity of fixed alkali is much greater than
" that of the flints, the melted maſs deliquiates by expoſure to a moiſt air, and
" becomes the liquor called *liquor of flints*, from which an earth may be preci-
" pitated, by adding an acid. This earth, which muſt have been originally
" the earth of the flints or ſand employed, is now rendered ſoluble in acids,
" and, as Mr. Pott ſays, is *calcareous*, or, as Mr. Beaumé affirms, is *argilla-*
" *ceous*."

Page 294. Dele *Note (m)*.

Page 301. *Notes, col.* 1. *line* 5. Inſtead of, " contain nitre, ſal ammoniac,
" or common ſalt, alum, or ſome vitriolic ſalt," read, " contain nitre, alum,
" or other vitriolic ſalt, and ſometimes ſal ammoniac or common ſalt."

The ſame page, Notes, col 1. *line penult.* Inſtead of the three ſucceſſive ſentences, the firſt of which begins thus, " Accordingly, in all the receipts,
" &c." and the laſt of which ſentences ends thus, " quickly plunges it in water,"
read the following: " This effect may be produced either by applying to the
" metal an aqua fortis, by which any remaining mercury, or allay of copper,
" or of other metals, that might diſcolor the gold, might be diſſolved; or by
" an aqua regia, which alſo would cleanſe its ſurface, but, at the ſame time, might
" diſſolve the gold itſelf, if applied a time ſufficiently long. Now, in all the
" receipts which I have ſeen for this ſaline compound, I have always obſerved
" nitre and alum, or ſome vitriol, together with other matters. From theſe
" ingredients, by expoſure to heat, an aqua fortis is evidently formed, the acid
" of the alum or other vitriol diſengaging the acid of the nitre. In ſeveral of
" theſe receipts I have ſeen added to the above-mentioned ſalts ſome ſal ammo-
" niac or common ſalt. By this addition, an aqua regia is formed, which may,
" as we have ſaid, alſo cleanſe the ſurface of the gold; but, as it may diſſolve
" part of the gold itſelf, even in the very ſhort time during which it is applied,
" the former compound, from which the nitrous acid only is diſengaged, ſeems
" to be preferable, and is now generally employed."

Page 336. *Notes, col.* 2. *line* 13. Inſtead of, " that it deliquiates," read,
" that glaſs-gall deliquiates."

Page 310. *Notes, col.* 1, *line* 5. Inſtead of, " but thoſe perſons," read,
" but this action of Moſes is evidently related, and ought to be conſidered,
" as miraculous, and therefore not explicable by natural means. As to thoſe
" perſons"

Ib. col. 2, *line* 1. Inſtead of, " will," read, " they will."

Page 312, *line* 20. Inſtead of, " and ſo fixed," read, " and will become ſo
" fixed."

Page 314. *Notes, col.* 2, *line* 3. After " fuſed," add a *comma*.

Page 478. *Notes, col.* 1, *line 6th from the bottom.* Inſtead of " coeval," read,
" coeval, or nearly coeval."

Page 316, *line* 38. Inſtead of, " behind," read, backwards."

Page 324, *line* 15. Add the following *Note*. " This propoſal is of a much
" older date than the Memoir of M. de la Condamine."

Page 361, *line* 20. Inſtead of, " citing," read, " exciting."

Page 409, *line* 23. Inſtead of, " method of friction," read, " method by " friction."

Page 425, *line* 15. Inſtead of, " By water," read, " With water."

Page 429. *Notes, col.* 2, *line laſt:* Inſtead of, " copper, iron," read, " iron, " copper."

Page 476. *Notes, col.* 1, *line* 4. Dele " up."

Page 479. *Notes, col.* 1, *line* 3. After " in a fluid ſtate," add, " and diſſolved " in water;"

Page 504. *Notes, col.* 2, *line 9th from the bottom.* Dele " alſo."

Page 552. *Notes, col.* 1, *line* 1. Inſtead of, " The petuntſe is improperly " ranked amongſt the claſs of earths called vitrifiable, becauſe, &c." read, " The petuntſe is ranked amongſt the earths called vitrifiable, improperly, as " I think, becauſe, &c."

Same page, col. 2; *line 3d from the bottom.* Inſtead of, " analiſed," read, " analyſed."

Page 555. *Notes, col.* 1, *line* 14. Inſtead of, " all of which are fuſible," read, " which are ſingly or jointly fuſible."

Page 591. *Notes, col.* 1, *line* 10. Inſtead of, " inexhauſted," read, " ex- " hauſted."

Same page, Notes, col. 1, *line* 24. Add, " But no inferences ought to be " drawn from experiments, which appear, from the author's own account, to " have been inaccurate, and not repeated."

Page 607. *Notes, col.* 1, *line* 4. Inſtead of, " or," read, " as."

Page 608. *Notes, col.* 1, *line* 9. Inſtead of, " unites ſo rapidly as to occaſion," read, " unites rapidly, and occaſions."

Page 742. *Notes, col.* 1, *line* 4. Inſtead of, " volatile, vitriolic," read, " vo- " latile vitriolic."

Page 815. *Notes, col.* 1, *line* 11. Inſtead of, " crown-glaſs," read, " flint- " glaſs;" and *line* 12, inſtead of, " flint-glaſs," read, " crown-glaſs."

EXPLANATION

OF THE

PLATES.

PLATE I.

Fig. 1. A Retort.
- A, Its belly or bowl.
- B, Its neck.

Fig. 2. Retorts of this form are called *Engliſh Retorts.*

Fig. 3. A Glass Alembic.
- A, The cucurbit.
- B, The head.
- C, The gutter within the head.
- D, The beak.

Fig. 4. A Long-Necked Glass Alembic.
- A, The body of the matraſs.
- B, The neck of the matraſs.
- C, The head of the alembic.

Fig. 5. A Glass Alembic *conſiſting of one Piece.*
- A, The cucurbit.
- B, The head.
- C, The aperture in the head.
- D, Its ſtopple.
- E, The mouth of the cucurbit.

Fig. 6. A Pelican.
- A, The cucurbit.
- B, The head.
- C, The aperture in the head with its ſtopple.
- D, The two curved ſpouts.

Fig. 7. A Row *of* Aludels.

FIG 8. A COPPER ALEMBIC.

A, The body or cucurbit.
B, The neck.
C, The head.
D, The beak, noſe, or ſpout.
E, The refrigeratory or cooler.
F, Its cock.
G, The receiver.

FIG. 9. A MUFFLE.

FIG. 10. *A perpendicular ſection of a* CUPPEL *or* TEST. The curve line repreſents the bottom of the cavity that contains the metal. The plan or any horizontal ſection of a cuppel is a circle.

FIG. 11. AN INGOT-MOULD, into the cavities of which melted metals are poured.

FIG. 12. AN APPARATUS *for* DISTILLING, by which the vapors that uſually eſcape in the ordinary method of diſtillation, are condenſed by paſſing into water or ſome other fluid. This apparatus was invented and deſcribed by Mr. Peter Woulfe. *See the Phil. Tranſ. Vol.* LVII.

A, a retort. Inſtead of this retort, in the diſtillation of ſome ſubſtances, may be ſubſtituted an iron pot with a ſtone-ware head, the neck of which is to be inſerted into the receiver, as in the preſent Figure.

B, a receiver, with a neck, into which the neck of the retort is to be inſerted; and a ſpout at its bottom, through which the diſtilled liquor paſſes into the bottle C; and an opening in the ſide at D, into which one end of a tube bent at right angles is inſerted. The other end of this tube paſſes into a veſſel H, open at both ends, the lower opening of which is cloſed with a glaſs ſtopple. Through the upper mouth of the veſſel H, one end of another tube I, bent twice at right angles, paſſes, while the other end of this tube is inſerted into a bottle F, and immerſed in the water or other fluid contained in that bottle. The crooked tubes are fitted into the mouth of the veſſel H by means of a cork, in which are two ſemicircular notches, through which the tubes paſs, and by lute.

The tube which paſſes into the bottle F is fitted into the mouth of this bottle by means of a cork, in which is a ſemi-circular notch. This mouth of the bottle F is not cloſed with lute.

The vapor that is raiſed from the ſubſtance expoſed to heat in the retort paſſes into the receiver B, where part of it is condenſed, and flows into the bottle C, while the reſt of it paſſes through the tube at D, into the veſſel H. From this veſſel, the vapor that ſtill remains uncondenſed paſſes through the crooked tube I, into the water contained in the bottle F, by which it is all condenſed excepting ſome elaſtic air, which is extricated in almoſt all diſtillations. This elaſtic air riſes through the water, and eſcapes at the ſemi-circular notch of the cork in the mouth of the veſſel, which is therefore not accurately cloſed by lute.

In moſt diſtillations a quantity of air is abſorbed at different times during the proceſs: and in this caſe the external air will preſs on the liquor in the bottle F, and force it through the tube I into the veſſel H, from which it may be taken by opening the ſtopple L.

The uſe of the veſſel H is to receive the liquor that may be thus raiſed from the bottle F, and to prevent it from paſſing into the receiver B, and from thence into the bottle C, where it might ſpoil the diſtilled liquor.

Mr. Woulfe, in the above-mentioned Philoſophical Tranſaction, relates ſeveral experiments made with this apparatus, from which the utility of this method of condenſing vapors by making them paſs into water, or ſome other fluid ſuited to the nature of the liquor diſtilled, appears.

Thus, by diſtilling twelve pounds of ſal ammoniac with quicklime and two gallons of water, he obtained eight pounds and a quarter of volatile alkaline ſpirit ſufficiently ſtrong to make eau de luce, which were collected in the bottle joined to the receiver; and upon adding two other gallons of water, he obtained ſeven pounds of weak volatile alkaline ſpirit. The water contained in the bottle F, which was ſix quarts, received an encreaſe of 2$\frac{1}{2}$ lb. in weight from the vapor condenſed in it; and from experiments made to compare the ſtrength of the alkali thus condenſed by the water with that of the ſtrongeſt alkaline liquor firſt obtained, and which we have ſaid was fit for making eau de luce, it was found, that the ſtrength of the former was to that of the latter as 140 to 76: hence the quantity ſaved by this apparatus was nearly equal to five pounds of volatile alkali ſufficiently ſtrong for making eau de luce. Mr. Woulfe obſerved a ſingular difference betwixt the alkaline liquor collected in the bottle joined to the receiver, and that which was condenſed in the water in the bottle F, namely, that a conſiderable heat was excited by mixing the latter alkaline ſpirit, but not the former, with vitriolic acid.

Another experiment is related, of the diſtillation of twelve pounds averdupoiſe of common ſalt with an equal quantity of oil of vitriol diluted with 7 lb. of water. In this operation 9 lb. 5 $\frac{1}{2}$oz of ſpirit of ſalt were collected in the bottle C, and 6 lb. 12 $\frac{1}{2}$oz. of the ſame ſpirit were condenſed in ſix quarts of water in the bottle F. The reſiduum weighed 18 lb. 6 oz. Hence in this operation there was a loſs of eight ounces, or $\frac{1}{70}$th part of the whole, moſt of which probably was elaſtic air. The ſtrength of the acid condenſed in the water was found, by experiment, to be to the ſtrength of the acid collected in the bottle C, as 200 is to 109. Theſe vapors, condenſed in water, were found to be more concentrated when the diſtillation was conducted ſlowly than when it was haſtened. It appeared alſo, that the moſt concentrated portion of the acid of ſea-ſalt is the moſt volatile, and that its ſtrength was to that of vitriolic acid (the ſpecific gravity of which was to that of water as 24 to 13), as 44 $\frac{1}{4}$ to 31. Experiments alſo ſhewed, that this vapor of ſpirit of ſalt condenſed in water contained no vitriolic acid, although the ſpirit collected in the bottle C did contain ſome of that acid.

The ſame ingenious chemiſt formed a *marine ether* by applying the vapor of rectified ſpirit of wine to this very concentrated vapor of marine acid, and by condenſing the united vapors in ſpirit of wine. This he effected by a well contrived apparatus. The necks of two retorts, one of which contained the ſpirit of wine, and the other the ſea-ſalt and vitriolic acid, from which the marine acid was to be diſtilled, opened into one receiver, where the vapors met: from this receiver the vapors paſſed through a tube into ſpirit of wine contained in a bottle; and thoſe which were not there condenſed paſſed through another tube into ſpirit of wine contained in a ſecond bottle. By a further diſtillation and cohobation, with ſlaked lime, of the ſeveral liquors collected in the receiver and in the ſpirit of wine in which the vapors were condenſed, a very ſubtle penetrating ether was produced. Mr. Beaumé had tried to procure a marine ether by uniting the vapors of the marine acid, and of ſpirit of wine; but he failed, becauſe he did not uſe an effectual method of condenſing the vapors.

Mr. Woulfe did not find that much advantage was gained by this method of condenſing vapors in water, in the diſtillation of the nitrous acid from nitre mixed with vitriolic acid, excepting that thus the noxious fumes are prevented from hurting the operators.

He thinks his propoſed method of condenſation may be applicable to the diſtillation of vitriolic acid, the ſulphureous fumes of which are difficultly condenſible; to the rectification of phoſphorus, the vapor of both which ſubſtances ought to be condenſed by means of water; to the rectification or diſtillation of vitriolic ether, the vapors of which ought to be condenſed in ſpirit of wine; and, laſtly, to many other diſtillations.

PLATE II.

FIG I. *An* ESSAY *or* CUPELLING FURNACE. This figure and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying. See Dr. Mortimer's Engliſh Edition, p.* 75.

" The aſſaying furnace is made in the following manner: 'Make with iron plates a hollow quadrangular priſm, eleven inches broad and nine inches high (*a a*, *b b*), ending at top in a hollow quadrangular pyramid (*b b*, *c c*), ſeven inches high, terminating in an aperture at top ſeven inches ſquare. This priſm muſt be cloſed at bottom with another iron plate, which ſerves as a baſis or bottom to it (*a a*). 2. Near the bottom make a door (*e*) three inches high, and five inches broad, that leads to the aſh-hole. 3. Above this door, and at the height of ſix inches from the baſis, make another door (*f*), of the figure of a ſegment of a circle, four inches broad at its baſis, and three inches and a half high in the middle. 4. Then faſten three iron plates on the fore-part of this furnace; let the firſt of them (*g g*), eleven inches long and half an inch high, be faſtened, ſo that its lower edge ſhall reſt againſt the bottom of the furnace, with three or four rivets, and in ſuch a manner, that there may be between the upper edge of the ſaid plate and the ſide of the furnace a groove ſo wide, as that the ſliders of the lower door (*k k*) may be put into it, and freely move backwards and forwards therein: theſe muſt be made of a thicker iron-plate. The ſecond iron-plate (*b b*), eleven inches long, three inches high, and perfectly parallel to the foregoing plate, muſt be faſtened in the ſpace between the two doors, in ſuch manner, that both the upper and the lower edge of it may form a hollow groove with the ſide of the furnace. One of theſe grooves, which is turned downwards, ſerves to receive the upper edges of the ſliders that ſhut the lower door (No. 2:) The other, that turns upwards, is to receive the inferior edges of the ſliders of the ſmall door above (No 3). The third plate (*i i*), which is like the firſt, muſt be rivetted cloſe above the upper door, in ſuch manner, that it may form a groove turning downwards, and contiguous to the upper edge of the upper door (No. 3.). 5. In order to ſhut both doors (No. 2. and 3.), you muſt adapt to each of them two ſliders made of iron-plates, that may move within the above-mentioned grooves (*k k*, *l l*); but the two ſliders belonging to the upper door (No. 3.) muſt have each a hole near the top; that is, one a ſmall hole one fifth part of an inch broad, and one inch and a half long (*m*); and the other a ſemi-circular aperture, one inch high and two inches broad (*n*). Let, beſides, each ſlider have a handle, that they may be laid hold of when they are to be moved. 6. Moreover, let five round holes, one inch broad, be bored in the furnace, two of which muſt be made in the fore-part of the furnace (*o o*), two others in the back-part, all at the height of five inches from the bottom, but three inches and a half diſtant from each ſide of the furnace; and, finally, a fifth hole (*p*), at the height of one inch above the upper edge of the upper door (*f*). 7. In ſhort, let the inſide of the furnace be armed wirh iron-hooks, jetting out half an inch, and about three inches diſtant from each other, to faſten the lute with which the furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular pyramid (*q*), three inches high, be adapted to the upper aperture (*d*) of the furnace, at the baſis ſeven inches broad, ending upwards in a hollow tube (*r*), three inches in diameter, two inches high, almoſt cylindrical, though ſomewhat convergent at top. This prominent tube ſerves to ſupport a funnel or flue, which is almoſt cylindrical, hollow, made of iron-plates, and two foot high, and which, when a very ſtrong fire is required, is put perpendicularly upon the ſhorter tube, in ſuch manner, that it enters cloſe into it, one inch and a half, or two inches deep, and may again be taken off at pleaſure, when there is no need of ſo ſtrong a fire. But this pyramidal cover (*q*) muſt beſides have two handles (*s s*) adapted to it, that it may be laid hold of, and thus be taken away or put on again: and that this, being put on the aperture (*d*) of the furnace, may not be eaſily thrown down, let an iron plate be rivetted to the right and left upper edge of the furnace (*c c*), and be turned down towards the inſide, ſo as to make a furrow open before and behind, into which the lateral edges of the cover may enter and be faſtened, and at pleaſure be moved backwards and forwards, whenever it muſt be put on, or moved. 9. Let a ſquare ledge, made of a thick iron-plate, be faſtened at top of the upper edge of the lower door (*e*); this is deſigned to ſupport the grate and the lute: but it muſt be made of two pieces, that it may be eaſily introduced into the cavity of the furnace. Thus you will have an aſſay-oven, which muſt afterwards be covered over on the inſide with lute. This you are to do as follows:

" That the fire may be better confined, and that the iron may not be deſtroyed by growing red-hot, the whole inſide of the furnace muſt be covered over with lute, one finger or one finger and a half thick. The lute fit for this is made of a maſs of clay mixed with ſand, and moiſtened with three or four times as much of ox-blood diluted with water *. But before you cover the inſide of your furnace with this lute, you muſt firſt put within the furnace ſmall iron bars, equal in length to the diameter of the oven, quadrangular, priſmatical, half an inch thick, having their extremities ſupported by a ſquare iron ledge, and three-fourths of an inch diſtant from each other; and you muſt faſten them ſo, that their flat ſides may be oblique with regard to the tranſverſe ſection of the furnace, and that the two oppoſite angles may look one upwards and the other downwards; the bars muſt not be laid flat, but edge-ways, by which ſituation you hinder the aſhes of the fuel of the fire from being detained too long between the interſtices of the ſaid iron-bars, and from making an obſtruction that would oppoſe the free draught of the air. The furnace being then covered over with lute, and dried up by a gentle heat, is at laſt fit for docimaſtical operations, and eſpecially for ſuch as muſt be performed in the aſſay-oven.

If then an operation is to be made in the furnace hitherto deſcribed, you muſt let through the four lower holes above deſcribed, of the furnace (*o o*) placed before and behind, and directly oppoſite to each other, two iron-bars one inch thick, and long enough that their extremities on every ſide may jut out of the holes a ſmall matter. Theſe ſerve to ſupport the muffle and its bottom (*See* PLATE I. FIG. 9.). You then introduce the muffle through the upper aperture of the furnace (*d*), and place it upon the above-deſcribed iron-bars, in ſuch manner, that the open fore-ſide of it be contiguous to the inward border of the upper door (*f*). The fuel of the fire is introduced through the top of the furnace (*d*); the cover of which, on this account, muſt be moveable and not very heavy (*q*). The beſt fuel for the fire is charcoal made of the hardeſt wood, eſpecially of beech, broken into ſmall pieces of the bigneſs of an inch, wherewith the muffle muſt be covered over ſome inches high. We then reject larger bits of coals, becauſe they cannot fall through the narrow interſtices, between the ſides of the muffle and thoſe of the furnace, and cannot, of courſe ſufficiently ſurround the circumference of the muffle. Whence it happens, that there are on every ſide places void of fuel, and the fire is either not ſtrong enough or unequal. But if, on the contrary, you uſe coals too ſmall, then a great part fall immediately through the interſtices of the grate into the aſh-hole; and the tendereſt particles of them turn too ſoon into *aſhes*, and by increaſing the heap of aſhes, obſtruct the free draught of the air, which is here greatly requiſite.

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* The beſt lute, and eaſieſt to be had at London, is a ſort of clay called Windſor loam, which muſt be mixt pretty ſtiff, and preſſed into the inſide of the furnace, firſt wetted with water; and when the clay begins to dry, it muſt be beat down cloſe to the ſides with a wooden mallet; then the unevenneſs and cracks filled up with freſh clay ſomewhat moiſter, ſo as to be made ſmooth and even with a trowel, and then left to dry gently; and if any cracks happen, they muſt again be filled up. *Note of Dr. Mortimer.*

Stourbridge clay, tobacco-pipe clay, or any other pure clay that is not fuſible by fire, may be uſed for this purpoſe. But as freſh clay ſhrinks and cracks very much in drying, it ought to be mixed with an equal quantity or more of coarſe white ſand, or of burnt clay groſsly powdered. Thus one part of Stourbridge clay, one part of coarſe white ſand, and one part of Stourbridge bricks groſsly powdered, being well mixed together, make a good lute for lining the inner ſurfaces of furnaces. To prevent the iron plates of the furnaces more effectually from calcination, their inner ſurfaces ought to be covered with a coating of charcoal-powder formed into a maſs or paſte, with as much freſh clay and water as are ſufficient for that purpoſe; and when this coating is dry, the above-mentioned lute may be applied. During the drying the lute ought to be daily beat with a mallet, that the ſpaces left by the ſhrinking of the clay may be cloſed, and the lute be rendered more compact.

" A perfect management of the fire is moſt commonly neceſſary in the performing of operations in this furnace; therefore the reader muſt give attention to what follows: If the door of the aſh-hole (*e*) is quite open; and the ſliders of the upper door (*f*) drawn towards each other, ſo as touch one another in the middle of the door; and if, beſides, the cover (*q*), and the funnel adapted to its tube (*r*), is upon the top (*q*) of the furnace, the fire will be then in the higheſt degree poſſible; though, in the mean time, it is hardly ever neceſſary to put the funnel on, except in a very cold ſeaſon: but if, after having diſpoſed the furnace in the manner juſt deſcribed, you put red burning coals into the open upper door (*f*) of it, the fire is ſtill more increaſed thereby: however, this artifice is never, or very ſeldom, neceſſary. When you ſhut the upper door with only that ſlider that has a narrow oblong hole in it (*m*), then the heat becomes a little leſs; but it diminiſhes ſtill more when you ſhut the door with the other ſlider that has in it the ſemi-circular hole (*n*), which is larger than that of the firſt ſlider: nay, the heat again is leſs when you take away the funnel put at top of the cover: finally, the door of the aſh-hole being either in part or totally ſhut, the heat is ſtill diminiſhed, becauſe the draught of the air, ſo neceſſary to excite the fire, is thereby hindered: but if, beſides all theſe, you likewiſe open the upper door quite, then the cold air, ruſhing into the muffle, cools the bodies put under it, that are to be changed, to a degree never required in any operation, and ſuch as will entirely hinder the boiling of lead. If, during the operation, the fire begins to decay, or to grow unequal, it is a ſign that there are places void of coals between the ſides of the furnace and thoſe of the muffle; therefore, in this caſe, you muſt ſtir your coals on every ſide with an iron-rod, which is to be introduced through the upper hole (*p*) of the furnace, that they may fall together, and thus act in a proper manner and equally.

" However, you are to obſerve concerning the regimen of the fire juſt deſcribed, that though the *apparatus* is made with all the exactneſs mentioned, nevertheleſs the effect does not always anſwer it. The cauſe of which difference has moſt commonly its origin in the various diſpoſitions of the air; for as every fire is more excited by coals in proportion as the air, more condenſed, and more quickly agitated, ſtrikes them more violently (which the effect of bellows plainly ſhews); it thence appears, that in warm and wet weathers, when the atmoſphere is light, the fire muſt be leſs efficacious in furnaces; that likewiſe, when ſeveral furnaces, ſituated near each other, are burning at the ſame time, the fire is in part ſuffocated; becauſe the ambient air is thereby rendered more rare and lighter. The ſame effect is produced by the ſun, eſpecially in ſummer-time, when it ſhines upon the place where the furnace is ſituated. The atmoſphere, on the contrary, being heavier in cold dry weather, excites a very great fire.

" The heat of the fire acts the ſtronger upon the bodies to be changed, as the muffle put in the furnace is leſs; as the ſaid muffle has more and larger ſegments cut out of it; as the ſides of this muffle are thinner; in ſhort, as there are more veſſels placed in the hinder part of the muffle; and on the contrary. In this caſe, when many of the conditions requiſite for the exciting of fire are wanting, then indeed the artificer, with all his ſkill, will hardly be able to excite the fire to a ſufficient degree, in order to perform operations well, in common aſſay-ovens, even though he uſes bellows, and puts coals into the upper door of the furnace. For this reaſon, I have put the grate almoſt three inches below the muffle, leſt the air, ruſhing through the aſh-hole, ſhould cool the bottom of the muffle, which happens in common aſſay-ovens; and again, that the ſmaller coals, almoſt already conſumed, and the aſhes, may more eaſily fall through the interſtices of the grate, and the larger coals ſtill fit to keep up the fire be retained. Finally, I have added the above-mentioned funnel, that the blowing of the fire being, by means of it, increaſed as much as poſſible, this might at laſt be carried to the requiſite degree; for the fire may always be diminiſhed, but not always be increaſed at pleaſure, without the aſſiſtance of a proper *apparatus.*"

FIG 2. This figure repreſents a furnace called an ATHANOR. *See* ATHANOR. This figure and the following deſcription are copied from *Cramer's Art of Aſſaying.* "This furnace is uſed for the diſtillation of acid ſpirits, for calcinations, cementations, &c. As theſe operations require a long and conſtant fire, an athanor is uſeful, becauſe it can contain as much freſh fuel as will keep up the fire for many hours together, and admits of a different, an accurate, and moſt conſtant regimen of the fire.

"Let then, 1ſt, a ſmall ſquare hollow tower *(a a a a)* be conſtructed of ſuch *ſtones,* [or of bricks made of *Stourbridge clay,* or *Windſor loam,*] as may reſiſt the fire; let the ſides of it be ſix inches thick, and forming a ſquare cavity within, of ten inches on each ſide *(b b b b).* The height of it is determined according as it is to keep up the fire long, without any addition of new fuel: five or ſix feet are moſt commonly ſufficient. 2. At the bottom of this tower make an opening (*c*), ſix inches broad, and as many inches high; hang to it an iron door, being on every ſide one inch broader than the opening, and ſuch as may ſhut it very cloſe: for which purpoſe the external edge of this opening muſt be excavated all round in ſuch manner, that it may form a groove one inch broad, into which the edges of the door may be received. 3. At the diſtance of ten inches from the bottom of the tower, put a grate *(d)*, made of priſmatical, quadrangular iron-bars, one inch thick, and three quarters of an inch diſtant from each other: let alſo each of theſe iron bars be ſo ſituated with regard of the tower, that the two oppoſite acute edges of each may look perpendicularly, one downward, the other upwards, that, by this means, the aſhes may eaſily fall into the aſh-hole. 4. Make above this grate an opening circular at top *(e)*, ſix inches high, ſeven inches broad, that may, as well as the aſh-hole. (No. 2,) be open and ſhut with an iron door. 5. Adapt to the top of the tower an iron cover *(f)*, exceeding the aperture of the tower all around two inches, and having a handle, wherewith it may be eaſily taken away, and put on again. Thus you are to make the furnace called in I at n, *furnus primarius.* 6. Then cut out in any ſide of the tower, for inſtance, in the left, an oblong ſquare aperture, going up obliquely towards the outſide *(g g)*, four inches and a half high, ten inches broad, having its inward inferior edge, one inch and a half, or two inches above the grate (*d*) ; that by the intervening of this hole, the cavity of this tower may communicate with another immediately to be deſcribed. 7. Nearly over-againſt the ſame ſide of the tower, make a cavity with ſtones, whoſe inferior part muſt be a hollow priſm, (*h*, *h*, *h*, *h*,) ſix inches high, twelve inches broad, ending at top in a ſemi-cylindrical arch (*i*, *i*,) deſcribed by a *radius* of ſix inches; that by this means, the height of the whole cavity may be twelve inches in the middle. Let this anterior cavity be totally open, though, when requiſite, it is to be ſhut very cloſe with an iron plate (*k*, *k*,) whoſe inward ſurface is to be conſtructed in the ſame manner as is preſcribed for the ſliding door of the melting furnace, (Fig. 4,) and then luted two inches thick within. Moreover, let there be in the middle of this plate, a round hole, four or five inches in diameter, and let the circumference of this hole have an iron cylindrical border made to it, and prominent within; that by means of it, the lining of lute within may be ſupported, and kept from falling down eaſily. Let a notch one inch broad, and two inches deep, be made in the outward circuit of the aperture of this cavity, to receive the extremity of the plate that ſhuts the aperture. The hole of this plate, either is ſhut with a ſtopple, or ſerves to paſs the neck of the retort through. This plate likewiſe is faſtened with two bolts (*n*, *n*,), to be put horizontally with iron hooks (*o*, *o*, *o*, *o*,) driven into the wall near the edge of the aperture, ſo that one bolt may faſten the upper part of the plate, and the other the lower. 8. It is moreover proper, that the ſquare aperture (*g*, *g*,) through which the fire enters from the tower into the cavity hitherto deſcribed (No. 7.), may be ſhut and opened at pleaſure with an iron ſlider: for if this is not done, an exceſſive fire, employed ſometimes by an unexperienced hand, cannot be ſo eaſily checked. For this purpoſe, let a ſlit half an inch broad, and eleven inches long, be left in the wall that conſtitutes the upper part of the cavity (No. 7,), and is contiguous to the tower; ſo that it may exceed the length of the ſquare aperture (*g*, *g*,) a ſmall matter on every ſide, and reach before and behind into the ſmall groove, going down along the perpendicular ſides of the ſaid aperture, (*g*, *g*,) and retain the iron-ſlider to be put into it to keep it ſteady. However, let this iron-ſlider be, ſix lines thick, eleven inches broad, and five inches high; and let a couple of ſmall iron-chains (*p*, *p*,) be faſtened on each ſide of its upper edge, wherewith the ſlider may be lifted up and let down again. Therefore, let a couple of ſtrong iron-nails be drove into the contiguous wall of the tower, perpendicularly over thoſe places in which the ſaid ſmall chains are faſtened to the iron-ſlider; that any of the links of the chains may be ſuſpended on them at pleaſure. Moreover, let the upper edge of the ſlit above deſcribed be entirely ſhut up with ſtones and cement, leaving only two ſmall holes through which the ſmall chains may be paſſed. On the left of this cavity (No. 7.), and at the diſtance of eight inches from the bottom of it, let a ſquare (*q*, *q*, *q*, *q*,) chimney or funnel be erected with *bricks*, three inches and a half in the clear, four foot high, and a ſmall matter convergent upwards, ſo that the diameter of it at top may be three inches. This funnel muſt be contrived to be ſhut cloſely with an iron-ſlider, having a handle to it (*r*, *r*,) which ſlider muſt move freely between a double iron ſquare frame faſtened in the walls of the funnel, at ſuch a height from the hearth as ſhall ſeem convenient to any artificer. 10. Below this chimney, let a ſquare aperture be made, like the foregoing (No. 6, *g*, *g*,), leading obliquely up to the bottom of another cylindrical cavity (*u*, *u*, *u*, *u*,) which is eight inches deep, deſcribed by a *radius* of ſix inches, open at top, and then converging inwardly into a border one inch thick, and ſix lines broad, deſigned to ſupport an iron-pot. Likewiſe, cut in the anterior wall of this cavity, and at the upper part of its mouth, a ſegment two inches and a half deep, five inches broad, and ſtooping forward (*v*, *v*,) to receive the neck of the retort. 11. To this cavity (No. 10.) belongs an iron-pot (*w*, *w*,) eleven inches broad, and about nine inches deep, which muſt be encompaſſed with an iron ring (*x*, *x*,) one inch broad, and faſtened at the diſtance of one inch and a half from the upper end of the pot. Let a ſegment (*y*) be likewiſe cut off the upper edge of this pot, which ſegment muſt be four inches and a half deep, and five inches broad: the iron-ring juſt deſcribed muſt be bent all round the edges of this ſegment. 12. Over-againſt the aperture (*t*, *t*,) which communicates from the firſt cavity (No. 7.) into the ſecond (No. 10.), let another ſuch aperture (*z*) be made, two inches diſtant from the bottom of the ſecond cavity (No. 10.) perfectly like the foregoing (*g*, *g*, *t*, *t*,) and communicating obliquely upwards with a third cavity (1, 1, 1, 1,), like and equal to the ſecond cylindrical cavity (*u*, *u*, *u*, *u*,); that the fire may paſs from the latter into the former. 13. In the hinder part of the wall which makes the aperture juſt mentioned (*z*), let a chimney like the foregoing (*q*, *q*, *q*, *q*,), and of the ſame height (2, 2, 2, 2,), be erected, which may be ſhut with a ſlider like that (3). 14. Finally, on the left ſide of the third cavity let an aperture be made in the ſame manner (4), and like the foregoing ones (*g g t t z*); more remote however from the bottom of the cavity, without a paſſage at the other extremity, and communicating only with the cavity of the third chimney (5, 5, 5,), which muſt be erected in the ſame manner as the two foregoing ones (*q*, *q*, *q*, *q*. 2, 2, 2, 2,). Thus you will have a furnace very proper for a great many operations.

“ We are now to ſpeak of the uſe of the *athanor* juſt deſcribed; and chiefly to mention, to what operations each of its parts ſerve in particular, and then how the fire may and muſt be governed in it. 1. You muſt put at the upper arched door (*e*) of the tower, a ſemi-cylindrical muffle twelve inches long, which muſt be introduced through the door: which for this reaſon muſt be of the ſame height and breadth as that door, three quarters of an inch thick, and open behind, being ſhut there by the hinder part of the athanor, as far as which it muſt reach. For this purpoſe, a *tile* muſt be ſet upon the grate (*d*) to ſupport the muffle. Let alſo this muffle have ſmall pieces cut out near its baſis, as common aſſay-muffles. You may put under this muffle your cement pots, or ſuch bodies as muſt be calcined with a long and violent fire; which can be done without a muffle, though not ſo neatly. 2. In the firſt chamber (*b*, *b*, *b*, *b*, *i*, *i*,) you may make the moſt violent diſtillations with an open fire: for retorts or large veſſels are introduced into it, after you have taken away the door (*k*, *k*, *k*,) and are put either upon the hearth itſelf of this chamber, or upon a particular ſupport of ſtone. But you muſt place theſe veſſels in ſuch manner, that their necks may eaſily paſs through the hole of the door, when put on again: for which purpoſe, they chuſe a ſupport ſometimes higher, ſometimes lower, according to the different heights of the veſſels. When afterwards the door is put on again, and faſtened with both its bolts (*n*, *n*,), you muſt cloſe with lute all the chinks which lie open about the neck of the veſſel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the veſſel a cylindrical ſegment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminiſhed; leſt the recipient, which is always choſen a glaſs veſſel, ſhould ſplit. The recipient, which muſt be united with the other orifice of the ſaid ſegment, is ſupported either by the pavement, or by a certain kind of trivet, the conſtruction of which is ſuch, that it may be ſet lower or higher by means of three ſcrews. 3. In this ſame chamber, inſtead of diſtillations, you may alſo make cementations, calcination, &c. in which caſe the round hole of the iron-plate may be ſhut and again opened with a ſtopple, that one may view the inſide. 4. The ſecond and third cavities (*u*, *u*, *u*, *u*. 1, 1, 1, 1,) ſerve chiefly to ſuch operations as are made in baths [or beds] of *ſand*, *aſhes*, or *filings*. For inſtance, you put into each of theſe cavities a pot, (*v*, *v*,) and you ſtop with thin *lute* or with *ſand*, which muſt previouſly be moiſtened, the ſlit between the iron-ring (*x*, *x*,) and the border of the cavity, upon which this ring reſts. 5. Beſides, you may alſo make in theſe two cavities, diſtillations by a reverberating fire, as well as in the firſt: only the fire is leſs violent in theſe, though ſufficient to extract aqua fortis. You then take out the iron-pot (*v*, *v*,) and inverting it, you put it upon the mouth of the chamber; ſo that the brim of the pot, being the depth of one inch and a half above the iron-ring (*x*, *x*,) wherewith this pot is ſurrounded, may be received within the mouth of the cavity, and ſo that the ſegment cut in the pot (*y*) may, together with the ſegment cut out from the ſide of the cavity (*v*, *v*,) form a hole to let the neck of the veſſel through. 6. All the *apparatus* being thus ready, you firſt introduce through the top of the tower (*b*, *b*, *b*, *b*,) a few burning coals; and put upon them ſome of the unkindled fuel of the fire; that the cavity of the tower may, according as it is thought neceſſary, be filled either entirely or only in part. Then with all ſpeed you put upon it the iron-cover (*f*), and ſtrew the border of this on the outſide with *ſand*, or *aſhes*, which you preſs gently with your hands: for if you ſhould neglect this point, all the fuel contained in the tower would be kindled, and may endanger ſetting the houſe on fire.

We ſhall here annex a few general rules concerning the regimen of the fire in this furnace: for it is hardly neceſſary to explain all particulars, ſince practice will eaſily hint them to ſuch as ſhall be ever ſo little acquainted with Chemiſtry. The fire may be made very ſtrong, in the firſt chamber, (*b*,*b*,*b*,*b*,*i*,*i*,) when the door of the aſh-hole (*c*), and the funnel (*q*, *q*, *q*, *q*,) of the chamber is quite open, and when the iron-ſlider ſuſpended with chains (6. *p*, *p*,) does not hinder the fire from paſſing freely from the tower into this cavity. But the cloſer the funnel is ſhut, together with the door of the aſh-hole, the more the violence of the heat diminiſhes: and this will be ſoon effected, if the iron-ſlider ſuſpended with chains is let down in part: for the fuel contained in the tower burns at leaſt as high as the ſpace between the lower edge of the iron-ſlider and the grate (*d*). Obſerve beſides, in thoſe operations wherein the

round

round hole of the door is ſtopt with a plug, that when the ſtrongeſt fire is required, this hole muſt not be kept long open; becauſe the air ruſhing violently through it, ſoon cools the bodies put into the cavity. The operations above-mentioned may be performed in the ſecond and third chamber, in, and at the ſame time, and with the ſame fire, as they are in the firſt chamber; for the fire penetrates from the firſt cavity into the ſecond, and increaſes when the funnel (2, 2, 2, 2,) erected on it is opened: but before you do this, the funnel of the firſt cavity muſt be ſhut as much as that of the ſecond is opened. By the ſame means, you may hinder the fire, which ſerves for the operations made in the two firſt cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may alſo act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one or even both funnels of the other two cavities muſt be cloſed: thence it is plain, that you cannot kindle the ſtrongeſt fire in the third cavity, unleſs there be one equally ſtrong in the other two; and that, on the contrary, the heat in the third cavity may be rendered leſs, by cloſing its funnel; though it be violent in the others. The ſame is true of the ſecond cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt fire under the muffle placed within the upper door (*e*) of the tower, unleſs you have an equal fire in the firſt cavity, which fire may conſequently be increaſed, by ſhutting the door quite againſt the muffle (*e*), and diminiſhed by opening it; there being mean while an equal heat in the firſt chamber, and in the following ones. The reſt will eaſily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

a, The aſh-hole door.
b, The fire place door.
c, *c*, *c*, *c*, Regiſters.
d, The dome or reverberatory.
e, The conical funnel.
f, The retort in the furnace.
g, The receiver.
h, *h*, Iron bars to ſuſtain the retort.

FIG. 4, 5, 6, 7, *and* 8, repreſent a MELTING FURNACE. Theſe figures and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying Metals.*

"The melting furnace is made of iron-plates, the inner ſurfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1ſt. Make an hollow ellipſis, the focus's 12 inches aſunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may aſſume the figure. (*Fig.* 4,). 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter, and directly oppoſite (*c*, *c*,). 3dly, Then faſten two flat iron-rings (*d*), almoſt one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inſide of it with ſmall iron-hooks, jutting out about ſix lines, and three or four inches diſtant from each other. Theſe, together with the rings juſt mentioned, ſerve to faſten the lute. Thus will the body of the furnace be made: only you muſt add at the outſide two iron-handles (*e, e,*) to be rivetted on each ſide of it, that it may be taken hold of and moved. 4thly, Then make the cover of the furnace, which may be formed like the part cut off from the ellipſis (See *Fig.* 5,). Let this have an opening (*b*) made in it, four inches high, five inches broad at bottom, and four inches at the top; and adapt to this an iron door hung on hinges to ſhut it cloſe, and having at the inſide a border faſtened to it, anſwering exactly to the circumference of the door, and as prominent inwardly as the thickneſs of the lute to be applied to it requires: for the ſame purpoſe, let ſmall iron-hooks be faſtened to the inſide of the door, which is intercepted by the ſaid border. And leſt this cover ſhould be burnt within by the force of fire, you muſt cover the inſide of it over with the ſame lute mentioned before for the aſſay-oven: therefore it muſt be likewiſe furniſhed with a ring and iron-hooks to faſten the lute; as was ſaid before, when we ſpoke of the body of this furnace. Beſides this, you muſt faſten two iron-handles (*Fig.* 5, *c, c,*) on the outſide of this cover. Then a round hole muſt be made in the top of it, being three inches in diameter, prolonged into a hollow tube (*d*) almoſt cylindrical, and a few inches high, upon which the iron-funnel deſcribed may, in caſe of neceſſity, be put after the manner mentioned in the ſame place where we ſpoke of the aſſay-oven. 5thly, After this, the lining of both the body and cover of the furnace within is made in the ſame manner above-deſcribed. Moreover, you muſt make for this furnace two moveable bottoms, *viz.* one to receive the aſhes, and admit the air; the other to ſerve for reductions. The firſt is made with an iron-plate, formed into a hollow cylinder, open at top, and to be ſhut at bottom with an orbicular iron-plate, as with a baſis, five inches high, and of ſuch a diameter, as that it may receive the inferior orifice of the body of the furnace (*Fig.* 4,) the depth of half an inch (*See Fig.* 6.): therefore let an iron-ring (*c*) half an inch broad, be faſtened on the inſide of the ſaid bottom, and at the diſtance of half an inch from its upper border, to ſupport the body of the furnace put into it. Again, let this bottom have a ſquare door, four inches high, and as many inches broad, that may be ſhut cloſely with a door hung on hinges, that you may by means of it increaſe or diminiſh the draught of the air, and thus govern the fire at pleaſure. Then, on the left ſide of this door, and at about half the height of this bottom part, let a round hole (*d*) be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the ſame matter and figure as the foregoing: let it be likewiſe of the ſame diameter, but two inches higher, ſo that it may be of the height of ſeven inches. Likewiſe let it have round it a like iron-ring below its upper border, to ſupport the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high (*Fig.* 7. *c.*), be cut out juſt below the ring in the ſide of this bottom part; then let another round hole be made in the left ſide of this firſt hole, fit to admit the pipe of the bellows (*d*). Further, let another round hole like the foregoing (*e*) be made on the right, and at the diſtance of one inch from the bottom: then let the whole inſide of this bottom-part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that repreſented by the line (*f, g, h,*). The matter of which this is made is common lute pulveriſed, paſſed through a ſieve, and mixed with ſuch a quantity of duſt of charcoal, ſifted in the ſame manner, ſo that the mixture being moiſtened and preſſed down, may at leaſt be lightly coherent. Of this matter preſſed on the bottom of the bottom-part a bed is made, like a ſegment of a ſphere, having in the middle a ſmall cavity ſomewhat lower, and made extremely ſmooth, after the manner mentioned before when we ſpoke of large aſh-veſſels or teſts.

This furnace is chiefly fit for fuſions, which may be made in it with and without veſſels. When you are to melt with a veſſel, put the body of the furnace (*Fig.* 4.) upon the firſt bottom (*Fig.* 6.), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace (*Fig.* 4. *c*, *c*); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or ſquare *tile*, very ſmooth every where, warmed, and perfectly dry: otherwiſe, the veſſels put upon it, eſpecially the large ones, are eaſily ſplit by the moiſt vapors coming out of it in the operations. Let the height and width of this *ſtone* be a ſmall matter broader and higher than the bottom of the crucible or pot to be ſet upon it; for if it were leſs high, the bottom of the veſſel could not be ſufficiently warmed; and if it were leſs broad, the veſſel might eaſily fall from it: then put upon this *tile* the veſſel containing the matter to be melted, and ſurround it immediately with coals on every ſide, which muſt be ranged according to the method preſcribed before, in our deſcription of the aſſay-furnace: then you govern the fire, by opening and ſhutting the door of the aſh-hole (*Fig.* 6. *b*): you excite it by putting the cover (*Fig.* 5.) upon the body of the furnace; and if, beſides, you put a funnel upon the cylindrical mouth (*d*) of this cover, the melting fire becomes ſtill more violent: but if you moreover introduce the bellows through the hole of the bottom part (*Fig.* 6. *d*); and the joint of the furnace with the bottom part, and the door of the aſh-hole, unleſs it can be ſhut very cloſe, being exactly ſtopt with thin lute [*or Windſor loam*], the fire thus excited by the blaſt of the bellows is carried to the higheſt degree, and far ſurpaſſes that which may be made in a Smith's forge. Another advantage of this method is, that the veſſels are not ſo eaſily broken, becauſe the blowing of the bellows cannot affect them immediately, and becauſe a fire perfectly equal is excited on every ſide. One may eaſily examine with this *apparatus*, how *ſtones* are affected by the violence of the fire only. Now, if you have a mind to perform any operation without a veſſel, and with a naked fire: for inſtance, to melt and reduce the *calxes* or *ſcorias of copper*, *tin*, *lead*, and *iron*, or the ores of theſe metals; the body of the furnace muſt be put upon the other pedeſtal, having a bed in it (*Fig.* 7.). However, you muſt, before this, open with a knife the oblong hole (*c*), and the round one (*d*) of this bottom part, which are ſtopped with the lute ſticking to the inſide: then you apply at the round hole (*d*) on the left ſide of the bellows, in ſuch manner that the nozzle of it, being directed obliquely downwards, may blow ſtrongly againſt the bed (*f*, *g*, *b*): by this means, all the aſhes that fall into the bed are blown away, and the ſtrength of the fire determined to ſuch a degree, that all the melted bodies that fall into the ſaid bed remain in their ſtate of fuſion; and were it otherwiſe, the melted bodies would immediately wax cold, and adhere in grains to the bed, *whereas they ought to have melted into one regulus.* The oblong hole in the fore-part of this bottom-part (*c*) ſerves to diſcover, by means of a poker, whether the matter in the bed be melted or not: it ſerves likewiſe to take away through it whatever might ſtop the bellows, and in ſome caſes to take away the *ſcoria*: then you put firſt coals into the furnace one ſpan high, and blow them well with the bellows, to make them burn, that the bed may be very hot before the matter to be melted is put into it; for if this is not previouſly done, the melted maſs ſeldom runs into a *regulus*, but remains diſperſed among the *ſcorias*, which ſoon grow hard. The bed being well heated, and freſh coals added to the fire, put into it ſuch quantity of the matter to be melted as cannot hinder the fire from being carried to the requiſite degree; which cannot be determined otherwiſe than by experience: again, put freſh coals, and upon them another quantity of the matter to be melted; they may be, like *ſtrata*, one upon another: but if the maſs, once melted, could not long ſuſtain the ſtrength of the fire, or if you had a mind to melt a greater quantity of matter than what can be contained in the bed, you muſt open the round lower hole (*Fig.* 7. *e*), that you may make a channel paſſing from that hole through the lute, and reaching to the ſmall cavity at the bottom of the bed (*g*): to this hole, at the outſide, apply an earthen diſh like the bed within, or any other proper recipient, ſurrounded with burning coals, into which the matter melted, running from the bed through the hole (*Fig* 7. *e.*), may be collected, as is repreſented by *Fig.* 8.

FIG. 9. A tranſverſe ſection of a FURNACE in which SULPHUR is obtained *by diſtillation* from pyrites. In this furnace are placed ten or twelve tubes, one of which is repreſented in this ſection (7), lying acroſs the whole breadth of the furnace. Theſe tubes are open at both ends. At the larger end, the mineral, form which the ſulphur is to be diſtilled, is to be introduced; and then the opening is to be cloſed with an earthen ſtopper. The ſmaller end opens into a caſt-iron receiver (8), which receives the ſulphur that is diſtilled or eliquated. To prevent the crude mineral from paſſing into the receiver, a ſtar-like piece of baked earth is placed in the neck or ſmaller end of the tube, along with the ſulphur. Each furnace contains ten or twelve ſuch tubes. The length of the whole furnace is therefore evidently much greater than its breadth. The tubes are about four feet long, ſomewhat of a conical form, ſix or eight inches wide at their larger end, and three quarters of an inch at their ſmaller end.

1 The walls of the long ſides of the furnace.
2. The aſh-hole.
3. The grate made of bricks.
4. The fire-place.
5. The paſſage for the flame to the upper part of the furnace.
6. The two walls of the long ſides of the furnace which ſupport the tubes.
7. A tube placed acroſs the furnace.
8. A ſquare caſt-iron receiver.
9. Two holes in the roof of the furnace through which the ſmoke eſcapes. There are generally ten or twelve ſuch holes in different parts of the roof, ſome of which are occaſionally cloſed. *See a further deſcription of*

this furnace, and of the operation of extracting ſulphur, at the article SMELTING *of* ORES.

FIG. 10. This figure repreſents a tranſverſe ſection of a FURNACE *for* PURIFYING SULPHUR *by* DISTILLATION. *See* SMELTING *of* ORES.

1. The foundation of the wall ſunk under ground.
2. The ſide-wall.
3. The back-wall.
4. The aſh-hole.
5. The grate.
6. The fire-place.
7. Two holes through which the ſmoke eſcapes.
8. The inner chamber of the furnace.
9. An iron cucurbit or pot.
10. A neck made of earthen-ware.
11. The veſſel called the fore-runner.
12. A receiver.
13. A banquette or ſtep raiſed to ſupport the fore-runner. In this furnace, which is of an oblong ſhape, generally five or ſix ſuch ſetts of diſtilling veſſels are placed on each ſide.

FIG. 11. Repreſents a *quantity of ore piled up to be roaſted.*

1. Two ſides or faces of the pile. All the ſides of it are covered with ſmall ore.
2. The upper part of the pile, where holes or cavities are ſeen in which the ſulphur of the ore is collected.
3. An opening where part of the pile has fallen down, and in which the ſulphur is ſeen dropping down.
4. A plank to keep off the wind. *See* SMELTING *of* ORES.

FIG. 12. *A Section of the above Pile.*

1. The wood to make the fire.
2. Some charcoal for the kindling of the fire.
3. A channel formed by a wooden tube or pipe.
4. The large lumps of ore.
5. Small ore.
6. Finer ore, or duſt of ore.
7. The ſubſtance called *vitriol,* that is, a half roaſted ore powdered.

FIG. 13. Repreſents a longitudinal ſection of the FURNACE *at* RAMMELSBERG. *See a deſcription of this furnace at the article* SMELTING *of* ORES *of* SILVER.

1. Foundation of the maſonry in the ground.
2. A part of the back wall.
3. The tuyere.
4. Channels to carry off moiſture.
5. The covering ſtone of theſe channels.
6. A bed of ſcoria.
7. The caſe or caſſe made of bricks.
8. A bed of clay.
9. A bed of ſifted ore and ſubſtance called vitriol.
10. The charcoal which is thrown into the caſſe previous to the filling of the furnace with ore and fuel.

11. A